AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT	1. CONTRACT ID CODE	PAGE 1 OF PAGES 4

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. *(If applicable)*
AM-0001	12/27/01		

6. ISSUED BY CODE

US ARMY ENGINEER DISTRICT, HONOLULU
CORPS OF ENGINEERS, BUILDING S-200
FORT SHAFTER, HAWAII 96858-5440
CONTRACT SPECIALIST: RENEE M. HICKS

7. ADMINISTERED BY *(If other than Item 6)* CODE

8. NAME AND ADDRESS OF CONTRACTOR *(No., street, county, State and ZIP Code)*

CODE FACILITY CODE

(X) 9A. AMENDMENT OF SOLICITATION NO.

X DACA83-02-R-0003

9B. DATED *(SEE ITEM 11)*
12/07/01

10A. MODIFICATION OF CONTRACT/ORDER NO.

10B. DATED *(SEE ITEM 13)*

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☒ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☐ is extended, ☐ is not extended.

Offer must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:

(a) By completing Items 8 and 15, and returning _____ copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. Accounting and Appropriation Data *(If required)*

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS, IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

(X) A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: *(Specify authority)* THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.

B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES *(such as changes in paying office, appropriation date, etc).* SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).

C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:

D. OTHER *(Specify type of modification and authority)*

E. IMPORTANT: Contractor ☐ is not, ☐ is required to sign this document and return _____ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION *(Organized by UCF section headings, including solicitation/contract subject matter where feasible.)*
FY02 MCA PN 50846 COLD STORAGE FACILITY, AND FY01 RDT&E REPAIR WATER TANKS, U.S. ARMY KWAJALEIN ATOLL

(See Page 2 of 2 Pages)

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER *(Type or print)*		16A. NAME AND TITLE OF SIGNER *(Type or print)*	
15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
(Signature of person authorized to sign)		BY *(Signature of Contracting Officer)*	

1. CHANGES TO SPECIFICATIONS. Attached hereto are new and revised pages and sections to the specifications. The revision mark "(AM-0002)" is shown on each page.

A. REVISED PARAGRAPHS. The following are revised paragraphs to the specifications. Changes are indicated in bold. The following are new, revised, and deleted paragraphs to the specification.

Section 00100 - 52.236-27 “Site Visit - Construction (Alt I)”
S-36.4 “Pre-Proposal Conference”

Section 00010 - Bidding Schedule

WATER TANKS
Section 02315 paragraph - 3.3.1
Section 03300 paragraph - 2.8

COLD STORAGE FACILITY
Project Table of Contents - Page: DIVISION 2 THRU 16-i
Submittal Register - Page: 1 - 32
Section 03300 - paragraphs: 2.14.1
Section 13038 - paragraphs: 1.2 and 2.1
Section 13040 - paragraphs: 1.4
Section 15070 - paragraphs: 1.4
Section 15652 - paragraphs: 1.2 and 1.2.1
Section 15895 - paragraphs: 1.4
Section 15990 - paragraphs: 1.2
Section 15995 - paragraphs: 1.1

B. NEW PAGES. The following paragraphs are added to the specification:

WATER TANKS
Section 03300 paragraphs - 2.3.6, 2.7, 2.9

COLD STORAGE FACILITY
Section 03411 - Pages 1 - 11

C. DELETED PAGES. The following paragraphs are deleted from the specifications:

Section 03300, paragraph 2.3.5,

2. CHANGES TO DRAWINGS

A. REVISED DRAWINGS (ISSUED). The following revised drawings replace like-numbered drawings and are issued herewith:

REV RING NO.	DRAWING NO.	SHEET NO.	LTR	REVISION DATE
1	841-21-01	T-1	a	11-30-01
2	841-21-01	S-1	a	11-30-01
3	841-21-01	S-2	a	11-30-01
4	841-21-01	S-3	a	11-30-10
5	841-21-01	S-4	a	11-30-10
11	841-21-10	M-1	a	11-30-10

B. REVISED DRAWINGS (ISSUED). The following revised drawings replace like-numbered drawings and are issued herewith:

WATER TANKS

REV RING NO.	DRAWING NO.	SHEET NO.	LTR	REVISION DATE
1	211-30-01	C-1	a	9/18/00
4	211-30-01	A-2	a	9/18/00
5	211-30-01	M-1	a	9/18/00
6	211-30-01	E-1	a	9/18/00
7	211-30-01	E-2	a	9/18/00
8	211-30-01	E-3	a	9/18/00
9	211-30-01	E-4	a	9/18/00
10	211-30-01	E-5	a	9/18/00

COLD STORAGE

REV RING NO.	DRAWING NO.	SHEET NO.	LTR	REVISION DATE
2.	432-10-01	T-2	a	
5.	432-10-01	C-2	a	
6.	432-10-01	C-3	a	
18.	432-10-01	A-1	a	
19.	432-10-01	A-2	a	
20.	432-10-01	A-3	a	
23.	432-10-01	A-6	a	
24.	432-10-01	A-7	a	
25.	432-10-01	A-8	a	
26.	432-10-01	A-9	a	
29.	432-10-01	A-12	a	
30.	432-10-01	A-13	a	
32.	432-10-01	A-15	a	
33.	432-10-01	A-16	a	
34.	432-10-01	A-17	a	
36.	432-10-01	A-19	a	
37.	432-10-01	A-20	a	

COLD STORAGE (continued)

REV RING NO.	DRAWING NO.	SHEET NO.	LTR	REVISION DATE
43.	432-10-01	S-2	a	
44.	432-10-01	S-3	a	
46.	432-10-01	S-5	a	

3. The proposal due date of March 1, 2002, 2:00 P.M. Hawaiian Standard Time (HST) remains unchanged.

SECTION 00010
PROPOSAL SCHEDULE

FY02 MCA Cold Storage Facility and
RDT&E Repair Water Tanks
Kwajalein Atoll, Marshall Island

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	AMOUNT
1.	Construct Cold Storage Facility (Includes$_____ for Mobilization and Demobilization)	1	Job	$_____
2.	Repair Water Tanks **(Includes$_____ for Mobilization and Demobilization)**	1	Job	$_____

TOTAL BASE SCHEDULE $_____

NOTES TO PROPOSAL SCHEDULE:

1. Failure to bid on all the items in the Proposal Schedule may cause the bid to be considered nonresponsive.

PAYMENT (S)

Compensation for all work to be performed under this contract will be made under the payment item(s) listed herein. The principal features of the Work to be included under the payment item(s) are noted. Work required by the drawings and specifications and not particularly mentioned shall be included in and be paid for under the contract price for the item to which the work pertains. Price(s) and payment(s) for the item(s) shall cover all work, complete and finished in accordance with the specifications, schedules, and drawings, and shall be full compensation for all work in connection therewith, including quality control and cost of performance-and payment-bond premiums as specified in the CONTRACT CLAUSES. Price(s) and payment(s) shall constitute full and final compensation for furnishing all materials, equipment, management, supervision, labor, transportation, fuel, power, water, and all incidental items necessary to complete the work, except as otherwise specified to be furnished by the Government. For the purpose of CONTRACT CLAUSE entitled "PROMPT PAYMENT FOR CONSTRUCTION CONTRACTS", the term "designated billing office" and "designated payment office" are as follows:

a. Billing Office
U.S. Army Corps of Engineers
Kwajalein Resident Office
PO Box 28
APO AP 96555-2528

b. Payment Office .
Central Accounting Office
PO Box 17073
Honolulu, HI 96817

Item numbers mentioned herein after correspond to the item numbers in the PROPOSAL SCHEDULE.

a. Item No. 1, Construct Cold Storage Facility, will be paid for at the contract price, complete in place and ready for use, including site preparation, building, water lines, sanitary-sewer system, storm-drainage system, stone protection work, pavement, concrete sidewalks, curbs, and gutters, security fencing, established of turf, mechanical work, electrical work, installation of Government-furnished property, testing, final connections, cleanup, and all incidental items necessary to complete the work.

b. Item No. 2, Repair Water Tanks, will be paid for at the contract price, complete in place and ready for use, including site preparation, testing, final connections, cleanup, and all incidental items necessary to complete the work.

- End of Section -

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SECTION 00100

CLAUSES INCORPORATED BY FULL TEXT

52.204-6 DATA UNIVERSAL NUMBERING SYSTEM (DUNS) NUMBER (JUN 99)

(a) Contractor identification is essential for complying with statutory contract reporting requirements. Therefore, the offeror is requested to enter, in the block with its name and address on the Standard Form 33 or similar document, the annotation "DUNS" followed by the DUNS number which identifies the offeror's name and address exactly as stated in the offer.

(b) If the offeror does not have a DUNS number, it should contact Dun and Bradstreet directly to obtain one. A DUNS number will be provided immediately by telephone at no charge to the offeror. For information on obtaining a DUNS number, the offeror, if located within the United States, should call Dun and Bradstreet at 1-800-333-0505. The offeror should be prepared to provide the following information:

(1) Company name.

(2) Company address.

(3) Company telephone number.

(4) Line of business.

(5) Chief executive officer/key manager.

(6) Date the company was started.

(7) Number of people employed by the company.

(8) Company affiliation.

(c) Offerors located outside the United States may obtain the location and phone number of the local Dun and Bradstreet Information Services office from the Internet Home Page at http://www.customerservice@dnb.com/. If an offeror is unable to locate a local service center, it may send an e-mail to Dun and Bradstreet at globalinfo@dnb.com.

(End of provision)

52.211-2 AVAILABILITY OF SPECIFICATIONS LISTED IN THE DOD INDEX OF SPECIFICATIONS AND STANDARDS (DODISS) AND DESCRIPTIONS LISTED IN THE ACQUISITION MANAGEMENT SYSTEMS AND DATA REQUIREMENTS CONTROL LIST, DOD 5010.12-L (DEC 1999)

Copies of specifications, standards, and data item descriptions cited in this solicitation may be obtained--

(a) From the ASSIST database via the Internet at http://assist.daps.mil; or

(b) By submitting a request to the--Department of Defense Single Stock Point (DoDSSP), Building 4, Section D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Telephone (215) 697-2667/2179, Facsimile (215) 697-1462.

(End of provision)

52.211-14 NOTICE OF PRIORITY RATING FOR NATIONAL DEFENSE USE (SEP 1990)

Any contract awarded as a result of this solicitation will be ___ DX rated order; X DO rated order certified for national defense use under the Defense Priorities and Allocations System (DPAS) (15 CFR 700), and the Contractor will be required to follow all of the requirements of this regulation. [Contracting Officer check appropriate box.]

(End of provision)

52.215-1 INSTRUCTIONS TO OFFERORS--COMPETITIVE ACQUISITION (MAY 2001)

(a) Definitions. As used in this provision--

“Discussions” are negotiations that occur after establishment of the competitive range that may, at the Contracting Officer's discretion, result in the offeror being allowed to revise its proposal.

In writing, writing, or written means any worded or numbered expression that can be read, reproduced, and later communicated, and includes electronically transmitted and stored information.

“Proposal modification” is a change made to a proposal before the solicitation's closing date and time, or made in response to an amendment, or made to correct a mistake at any time before award.

“Proposal revision” is a change to a proposal made after the solicitation closing date, at the request of or as allowed by a Contracting Officer as the result of negotiations.

“Time”, if stated as a number of days, is calculated using calendar days, unless otherwise specified, and will include Saturdays, Sundays, and legal holidays. However, if the last day falls on a Saturday, Sunday, or legal holiday, then the period shall include the next working day.

(b) Amendments to solicitations. If this solicitation is amended, all terms and conditions that are not amended remain unchanged. Offerors shall acknowledge receipt of any amendment to this solicitation by the date and time specified in the amendment(s).

(c) Submission, modification, revision, and withdrawal of proposals. (1) Unless other methods (e.g., electronic commerce or facsimile) are permitted in the solicitation, proposals and modifications to proposals shall be submitted in paper media in sealed envelopes or packages (i) addressed to the office specified in the solicitation, and (ii) showing the time and date specified for receipt, the solicitation number, and the name and address of the offeror. Offerors using commercial carriers should ensure that the proposal is marked on the outermost wrapper with the information in paragraphs (c)(1)(i) and (c)(1)(ii) of this provision.

(2) The first page of the proposal must show--

(i) The solicitation number;

(ii) The name, address, and telephone and facsimile numbers of the offeror (and electronic address if available);

(iii) A statement specifying the extent of agreement with all terms, conditions, and provisions included in the solicitation and agreement to furnish any or all items upon which prices are offered at the price set opposite each item;

(iv) Names, titles, and telephone and facsimile numbers (and electronic addresses if available) of persons authorized to negotiate on the offeror's behalf with the Government in connection with this solicitation; and

(v) Name, title, and signature of person authorized to sign the proposal. Proposals signed by an agent shall be accompanied by evidence of that agent's authority, unless that evidence has been previously furnished to the issuing office.

(3) Submission, modification, or revision, of proposals.

(i) Offerors are responsible for submitting proposals, and any modifications, or revisions, so as to reach the Government office designated in the solicitation by the time specified in the solicitation. If no time is specified in the solicitation, the time for receipt is 4:30 p.m., local time, for the designated Government office on the date that proposal or revision is due.

(ii)(A) Any proposal, modification, or revision received at the Government office designated in the solicitation after the exact time specified for receipt of offers is “late” and will not be considered unless it is received before award is made, the Contracting Officer determines that accepting the late offer would not unduly delay the acquisition; and--

(1) If it was transmitted through an electronic commerce method authorized by the solicitation, it was received at the initial point of entry to the Government infrastructure not later than 5:00 p.m. one working day prior to the date specified for receipt of proposals; or

(2) There is acceptable evidence to establish that it was received at the Government installation designated for receipt of offers and was under the Government's control prior to the time set for receipt of offers; or

(3) It is the only proposal received.

(B) However, a late modification of an otherwise successful proposal that makes its terms more favorable to the Government, will be considered at any time it is received and may be accepted.

(iii) Acceptable evidence to establish the time of receipt at the Government installation includes the time/date stamp of that installation on the proposal wrapper, other documentary evidence of receipt maintained by the installation, or oral testimony or statements of Government personnel.

(iv) If an emergency or unanticipated event interrupts normal Government processes so that proposals cannot be received at the office designated for receipt of proposals by the exact time specified in the solicitation, and urgent Government requirements preclude amendment of the solicitation, the time specified for receipt of proposals will be deemed to be extended to the same time of day specified in the solicitation on the first work day on which normal Government processes resume.

(v) Proposals may be withdrawn by written notice received at any time before award. Oral proposals in response to oral solicitations may be withdrawn orally. If the solicitation authorizes facsimile proposals, proposals may be withdrawn via facsimile received at any time before award, subject to the conditions specified in the provision at 52.215-5, Facsimile Proposals. Proposals may be withdrawn in person by an offeror or an authorized representative, if the identity of the

person requesting withdrawal is established and the person signs a receipt for the proposal before award.

(4) Unless otherwise specified in the solicitation, the offeror may propose to provide any item or combination of items.

(5) Offerors shall submit proposals in response to this solicitation in English, unless otherwise permitted by the solicitation, and in U.S. dollars, unless the provision at FAR 52.225-17, Evaluation of Foreign Currency Offers, is included in the solicitation.

(6) Offerors may submit modifications to their proposals at any time before the solicitation closing date and time, and may submit modifications in response to an amendment, or to correct a mistake at any time before award.

(7) Offerors may submit revised proposals only if requested or allowed by the Contracting Officer.

(8) Proposals may be withdrawn at any time before award. Withdrawals are effective upon receipt of notice by the Contracting Officer.

(d) Offer expiration date. Proposals in response to this solicitation will be valid for the number of days specified on the solicitation cover sheet (unless a different period is proposed by the offeror).

(e) Restriction on disclosure and use of data. Offerors that include in their proposals data that they do not want disclosed to the public for any purpose, or used by the Government except for evaluation purposes, shall--

(1) Mark the title page with the following legend: This proposal includes data that shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed--in whole or in part--for any purpose other than to evaluate this proposal. If, however, a contract is awarded to this offeror as a result of--or in connection with-- the submission of this data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the resulting contract. This restriction does not limit the Government's right to use information contained in this data if it is obtained from another source without restriction. The data subject to this restriction are contained in sheets [insert numbers or other identification of sheets]; and

(2) Mark each sheet of data it wishes to restrict with the following legend: Use or disclosure of data contained on this sheet is subject to the restriction on the title page of this proposal.

(f) Contract award. (1) The Government intends to award a contract or contracts resulting from this solicitation to the responsible offeror(s) whose proposal(s) represents the best value after evaluation in accordance with the factors and subfactors in the solicitation.

(2) The Government may reject any or all proposals if such action is in the Government's interest.

(3) The Government may waive informalities and minor irregularities in proposals received.

(4) The Government intends to evaluate proposals and award a contract without discussions with offerors (except clarifications as described in FAR 15.306(a)). Therefore, the offeror's initial proposal should contain the offeror's best terms from a cost or price and technical standpoint. The Government reserves the right to conduct discussions if the Contracting Officer later determines them to be necessary. If the Contracting Officer determines that the number of proposals that would otherwise be in the competitive range exceeds the number at which an efficient competition can be conducted, the Contracting Officer may limit the number of proposals in the competitive range to the greatest number that will permit an efficient competition among the most highly rated proposals.

(5) The Government reserves the right to make an award on any item for a quantity less than the quantity offered, at the unit cost or prices offered, unless the offeror specifies otherwise in the proposal.

(6) The Government reserves the right to make multiple awards if, after considering the additional administrative costs, it is in the Government's best interest to do so.

(7) Exchanges with offerors after receipt of a proposal do not constitute a rejection or counteroffer by the Government.

(8) The Government may determine that a proposal is unacceptable if the prices proposed are materially unbalanced between line items or subline items. Unbalanced pricing exists when, despite an acceptable total evaluated price, the price of one or more contract line items is significantly overstated or understated as indicated by the application of cost or price analysis techniques. A proposal may be rejected if the Contracting Officer determines that the lack of balance poses an unacceptable risk to the Government.

(9) If a cost realism analysis is performed, cost realism may be considered by the source selection authority in evaluating performance or schedule risk.

(10) A written award or acceptance of proposal mailed or otherwise furnished to the successful offeror within the time specified in the proposal shall result in a binding contract without further action by either party.

(11) The Government may disclose the following information in postaward debriefings to other offerors:

(i) The overall evaluated cost or price and technical rating of the successful offeror;

(ii) The overall ranking of all offerors, when any ranking was developed by the agency during source selection;

(iii) A summary of the rationale for award; and

(iv) For acquisitions of commercial items, the make and model of the item to be delivered by the successful offeror.

(End of provision)

52.215-20 REQUIREMENTS FOR COST OR PRICING DATA OR INFORMATION OTHER THAN COST OR PRICING DATA (OCT 1997)—ALTERNATE IV (OCT 1997)

I. Submission of cost or pricing data is not required.

II. Provide information described below: [Insert description of the information and the format that are required, including access to records necessary to permit an adequate evaluation of the proposed price in accordance with 15.403-3.]

52.216-1 TYPE OF CONTRACT (APR 1984)

The Government contemplates award of a firm fixed-price contract resulting from this solicitation.

(End of clause)

52.225-12 NOTICE OF BUY AMERICAN ACT/BALANCE OF PAYMENTS PROGRAM REQUIREMENT-- CONSTRUCTION MATERIALS UNDER TRADE AGREEMENTS (FEB 2000)

(a) Definitions. Construction material, designated country construction material, domestic construction material, foreign construction material, and NAFTA country construction material, as used in this provision, are defined in the clause of this solicitation entitled “Buy American Act--Balance of Payments Program--Construction Materials under Trade Agreements” (Federal Acquisition Regulation (FAR) clause 52.225-11).

(b) Requests for determination of inapplicability. An offeror requesting a determination regarding the inapplicability of the Buy American Act or Balance of Payments Program should submit the request to the Contracting Officer in time to allow a determination before submission of offers. The offeror shall include the information and applicable supporting data required by paragraphs (c) and (d) of FAR clause 52.225-11 in the request. If an offeror has not requested a determination regarding the inapplicability of the Buy American Act or Balance of Payments Program before submitting its offer, or has not received a response to a previous request, the offeror shall include the information and supporting data in the offer.

(c) Evaluation of offers. (1) The Government will evaluate an offer requesting exception to the requirements of the Buy American Act or Balance of Payments Program, based on claimed unreasonable cost of domestic construction materials, by adding to the offered price the appropriate percentage of the cost of such foreign construction material, as specified in paragraph (b)(4)(i) of FAR clause 52.225-11.

(2) If evaluation results in a tie between an offeror that requested the substitution of foreign construction material based on unreasonable cost and an offeror that did not request an exception, the Contracting Officer will award to the offeror that did not request an exception based on unreasonable cost.

(d) Alternate offers. (1) When an offer includes foreign construction material, other than designated country or NAFTA country construction material, that is not listed by the Government in this solicitation in paragraph (b)(3) of FAR clause 52.225-11, the offeror also may submit an alternate offer based on use of equivalent domestic, designated country, or NAFTA country construction material.

(2) If an alternate offer is submitted, the offeror shall submit a separate Standard Form 1442 for the alternate offer, and a separate price comparison table prepared in accordance with paragraphs (c) and (d) of FAR clause 52.225-11 for the offer that is based on the use of any foreign construction material for which the Government has not yet determined an exception applies.

(3) If the Government determines that a particular exception requested in accordance with paragraph (c) of FAR clause 52.225-11 does not apply, the Government will evaluate only those offers based on use of the equivalent domestic, designated country, or NAFTA country construction material, and the offeror shall be required to furnish such domestic, designated country, or NAFTA country construction material. An offer based on use of the foreign construction material for which an exception was requested--

(i) Will be rejected as nonresponsive if this acquisition is conducted by sealed bidding; or

(ii) May be accepted if revised during negotiations.

(End of provision)

52.233-2 SERVICE OF PROTEST (AUG 1996)

(a) Protests, as defined in section 33.101 of the Federal Acquisition Regulation, that are filed directly with an agency, and copies of any protests that are filed with the General Accounting Office (GAO), shall be served on the Contracting Officer (addressed as follows) by obtaining written and dated acknowledgment of receipt from:

U.S. Army Engineer District, Honolulu
Corps of Engineers, Bldg 230
ATTN: Directorate of Contracting, CEPOH-CT
Fort Shafter, HI 96858-5440

(b) The copy of any protest shall be received in the office designated above within one day of filing a protest with the GAO.

(End of provision)

52.236-27 SITE VISIT (CONSTRUCTION) (FEB 1995) – ALTERNATE I (FEB 1995)

(a) The clauses at 52.236-2, Differing Site Conditions, and 52.236-3, Site Investigations and Conditions Affecting the Work, will be included in any contract awarded as a result of this solicitation. Accordingly, offerors or quoters are urged and expected to inspect the site where the work will be performed.

(b) An organized site visit has been scheduled for--
*January 9, 2002 (Kwajalein Time) (9:00 a.m. to 3:00 p.m.) *
(c) Participants will meet at--Kwajalein
Due to limited logistical support, only one representative from each firm who has acquired the CD ROM may attend the site visit and preproposal conference. All Contractors that wish to attend MUST contact Mr. Rodney Leong at telephone no. (808)438-6940, facsimile no. (808) 438-8865, or e-mail address rodney.s.leong@poh01.usace.army.mil NO LATER THAN 14 Dec 01. Contractors shall provide full name, social security number, date of birth, place of birth, citizenship, name of company, position/title, home address, confirmation of flight reservations, point of departure, dates of entry and exit, and name of airline carrier to obtain an entry clearance. Contractors may only visit the site on day of the scheduled site visit and preproposal conference. The Government will only respond to questions submitted in writing via amendments to the solicitation. Questions regarding the solicitation should be submitted no later than 9 Jan 02.

52.236-28 PREPARATION OF PROPOSALS--CONSTRUCTION (OCT 1997)

(a) Proposals must be (1) submitted on the forms furnished by the Government or on copies of those forms, and (2) manually signed. The person signing a proposal must initial each erasure or change
appearing on any proposal form.

(b) The proposal form may require offerors to submit proposed prices for one or more items on various bases, including--

(1) Lump sum price;

(2) Alternate prices;

(3) Units of construction; or

(4) Any combination of paragraphs (b)(1) through (b)(3) of this provision.

(c) If the solicitation requires submission of a proposal on all items, failure to do so may result in the proposal being rejected without further consideration. If a proposal on all items is not required, offerors should insert the words “no proposal” in the space provided for any item on which no price is submitted.

(d) Alternate proposals will not be considered unless this solicitation authorizes their submission.

(End of provision)

S-36.4 PRE-PROPOSAL CONFERENCE (JUL 1995)

a. A pre-proposal conference will be conducted by the Government on January 9, 2002
* (Kwajalein time) in Kwajalein from 9:00 a.m. to 3:00 p.m. All planholders (prime contractors, subcontractors, and*
suppliers) are urged to attend this conference. Planholders who plan to attend should notify the Government of the number of attendees before the date of the conference. Notification can be made as
follows:

(1) Telephone: Insert phone no.
Point of Contact: Insert POC

(2) Mail: U.S. Army Engineer District, Honolulu
Corps of Engineers, Bldg 230
ATTN: Rodney Leong (808)438-6940
Fort Shafter, Hawaii 96858-5440

Due to limited logistical support, only one representative from each firm who has acquired the CD ROM may attend the site visit and preproposal conference. All Contractors that wish to attend MUST contact Mr. Rodney Leong at telephone no. (808)438-6940, facsimile no. (808) 438-8865, or e-mail address rodney.s.leong@poh01.usace.army.mil NO LATER THAN 14 Dec 01. Contractors shall provide full name, social security number, date of birth, place of birth, citizenship, name of company, position/title, home address, confirmation of flight reservations, point of departure, dates of entry and exit, and name of airline carrier to obtain an entry clearance. Contractors may only visit the site on day of the scheduled site visit and preproposal conference. The Government will only respond to questions submitted in writing via amendments to the solicitation. Questions regarding the solicitation should be submitted no later than 9 Jan 02.

b. Any questions planholders may have concerning the project, plans, or specifications should be submitted in writing, on letterhead stationery, sufficiently in advance of the conference, to permit preparation of answers, which will be provided at the conference. The questions should be faxed as soon as possible, and followed by an original through mail. Use the facsimile number and address shown in paragraph a. above. During the conference, written, signed questions will be accepted, and will be answered during the conference if time permits.

c. A complete record of the conference, including questions raised by planholders and answers provided by the Government, will be made and a copy furnished to all planholders. However, any answer, clarification, or explanation given at the conference will not qualify or change the terms of the request for proposal (including the plans and specifications). Unless the request for proposal is amended in writing, it will remain unchanged. If an amendment to the request for proposal is

issued as a result of the conference, normal procedures relating to issuance and acknowledgement of receipt will apply.

d. All costs incurred to attend and participate in the pre-proposal conference and any site visits (see paragraph e. below) will be at the expense of the planholder. This includes, but is not limited to, the cost of transportation, per diem, and hotel accommodations.

e. Refer to provision entitled SITE VISIT (CONSTRUCTION) in Section 00100 for information on the pre-proposal site visit.

[End of Statement]

S-36.2 MAGNITUDE OF THE PROPOSED PROJECT [FAR 36.204]

(a) Physical Characteristics: FY02 MCA, Cold Storage Facility, and FY01 RDT&E Repair Water Tanks, Kwajalein, U.S. Army Kwajalein Atoll. The work for FY02 MCA PN 50846, Cold Storage Facility is to construct a 22,000 SF, 315,000 CF cold storage warehouse, having two freezer and five chilled rooms with racking, and a contiguous ice plant. Supporting facilities include utilities, fire protection and alarm systems; paving, walks, curbs and gutters; stom drainage; information systems; and site improvements. Refrigeration load: 200 tons. Air conditioning: 20 tons. Demolish three buildings (112,100 CF) with asbestos abatement. The work for FY01 RDT&E, Repair Water Tanks, is to perform all work necessary to repair three existing 1 million gallon concrete water storage tanks (Facility Nos. 946, 947, 966), including piping. Contractors may visit the site subject to a two-week prior approval by the Commander, U.S. Army Kwajalein Atoll and proper entry clearance.

(b) Estimated Price Range: The estimated price range of this work is: between $25,000,000 and $100,000,000.

[End of Statement]

S-28.3 PENAL SUM AND FORM OF OFFER GUARANTEE

(Applicable to offers exceeding $100,000)

Each offeror shall submit with its offer a separate offer guarantee using Standard Form 24, Bid Bond, with good and sufficient surety or sureties acceptable to the Government, or other security as provided in the clause entitled OFFER GUARANTEE in the CONTRACT CLAUSES section. This security shall be in the form of twenty percent (20%) of the offered price or three million dollars ($3,000,000), whichever is less. The penal sum of the bond may be expressed in terms of a percentage of the offered price or may be expressed in dollars and cents.

Failure to submit a offer guarantee by the time and date set for receipt of proposals may be cause for rejection of a proposal, except as provided in provision 52.215-1, Instructions to Offerors--Competitive Acquisition.

[End of Statement]

K-2 RESTRICTIONS ON AWARD

(a) In view of stringent security considerations at Kwajalein Atoll, a contract under this solicitation shall be awarded only to a United States contractor or to a Marshall Islands contractor.

(b) Definitions. The following terms, as used in this clause only, shall have the following meanings:

(1) "Person" means an individual.

(2) "Firm" means a corporation or partnership.

(3) "Joint Venture" means more than one firm and/or person agreeing to submit a joint proposal under this solicitation.

(4) "United States" means the 50 states, the District of Columbia, Puerto Rico, the Commonwealth of the Northern Mariana Islands, and possessions as defined in FAR 2.101.

(5) "State" means any of the 50 States, the District of Columbia, Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Virgin Islands, American Samoa, or Guam.

(c) To qualify as a United States or Marshall Islands contractor, a person must be a citizen of the United States or the Republic of the Marshall Islands and, at the time of submitting a proposal under this
solicitation, must comply with all of the following:

(1) At least 80 percent of the principal management personnel employed in the United States and/or the Marshall Islands by that person shall be citizens of the United States or the Republic of the Marshall Islands;

(2) More than half of the permanent full time personnel employed in the United States and/or the Marshall Islands by that person shall be citizens of the United States or the Republic of the Marshall Island; and

(d) To qualify as a United States or Marshall Islands contractor, a firm must be incorporated in or organized under the laws of a State or the Republic of the Marshall Islands and, at the time of submitting a proposal under this solicitation, must comply with all of the following:

(1) The firm's principal place of business and headquarters shall have been in the United States or the Republic of the Marshall Islands for a minimum of two calendar years immediately preceding this solicitation;

(2) Tax returns, if required, shall have been filed by that firm in the United States or in the Republic of the Marshall Islands for a minimum of two tax years immediately preceding this solicitation;

(3) For a minimum of two full years immediately preceding the issuance of this solicitation (i) if that firm is a corporation, a continuous majority of the corporate officers shall have been citizens of the United States or the Republic of the Marshall Islands, or (ii) if that firm is a partnership, all of the general partners shall have been citizens of the United States or the Republic of the Marshall Islands, or shall have been incorporated in or organized under the laws of a State or the Republic of the Marshall Islands and shall meet all the requirements of (d) (1), (d) (2) and (d) (3) (i) above and (d) (5) below.

(4) That firm must employ citizens of the United States or the Republic of the Marshall Islands in at least 80 percent of its principal management positions in the United States and/or in the Marshall Islands; and

(5) That firm must employ citizens of the United States or the Republic of the Marshall Islands in more than half of its permanent, full-time positions in the United States and/or in the Marshall Islands.

(e) For a joint venture to quality as a United States or Marshall Island contractor, each member of the joint venture must meet all the requirements set out in (c) or (d) above, as appropriate.

(f) In addition, to qualify for award of a contract under this solicitation, a firm or person must have proven, as indicated by prior contracting experience in the United States and/or in the Marshall Islands, that it possesses the technical, managerial, and financial capability to successfully complete a project similar in nature and technical complexity to that described in this solicitation; and it must presently possess the technical, managerial and financial resources in the United States and/or in the Marshall Islands to perform the contract.

(g) Nothing in this provision shall be construed to prohibit award to a joint venture between United States and Marshall Islands contractors, so long as each member of the joint venture meets the criteria otherwise required by this provision.

[End of Statement]

SECTION TABLE OF CONTENTS

DIVISION 02 - SITE WORK

SECTION 02315

EXCAVATION, DEMOLITION, FILLING AND BACKFILLING

-- End of Section Table of Contents --

SECTION 02315

EXCAVATION, DEMOLITION, FILLING AND BACKFILLING

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORATION OFFICES

AASHTO T 180	(1997) Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and an 457-mm (18-in) Drop

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 33	(19999a) Concrete Aggregates
ASTM C 117	(1995) Material Finer Than 75 Micrometer (No. 200) Sieve in Mineral Aggregate by Washing
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM D 422	(1963; R 1998) Particle-Size Analysis of Soils
ASTM D 1556	(1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(1991) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.))
ASTM D 2487	(1993) Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(1996) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 2937	(1994) Density of Soil in Place by the Drive-Cylinder Method
ASTM D 3017	(1988; R 1993) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

ASTM D 4253	(2000) Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D 4318	(1995a) Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.2 DEGREE OF COMPACTION

Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557-91, Method C, for material that has no more than 30 percent retained on the 3/4 inch sieve and has more than 20 percent retained on the 3/8 inch sieve. Where the material does not meet these gradation requirements, AASHTO T 180 method D will be used. Where free draining soils, i.e., sand or gap-graded aggregate are to be compacted, use ASTM D 4253. The procedure will be abbreviated below as a percentage of laboratory density.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-09 Reports

Testing; FIO.

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Satisfactory Materials

Gravel fill consisting of imported crusher waste or base course conforming to State of Hawaii Standard Specifications for Road and Bridge Construction, 1994, 1-1/2 inches maximum size. Gravel fill shall consist of clean, crushed, nonporous rock or crushed gravel. The maximum size shall be 1-1/2 inches and no more than 2 percent by weight shall pass through the No. 4 size sleeve. Sand fill shall conform to ASTM C 33 No. 10 to No. 100.

2.1.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as satisfactory which contains root and other organic matter, and stones larger than 2 inches. The Contracting Officer shall be notified of any contaminated materials.

2.1.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC,

ML, CL, MH, and CH. Materials classified as GM, GP-GM, GW-GM, SW-SM, SP-SM, and SM shall be identified as cohesionless only when the fines are nonplastic. Testing required for classifying materials shall be in accordance with ASTM C 117, ASTM C 136, ASTM D 422 and ASTM D 4318 as applicable.

PART 3 EXECUTION

3.1 DEMOLITION

Concrete slab shall be demolished to limits as required for new work. The Contactor shall take necessary precautions to prevent damage to adjacent walls, foundation and improvements which are to remain.

3.2 EXCAVATION

Excavation shall conform to the dimensions and elevations indicated for each structure, and footing except as specified, and shall include trenching for utility and foundation drainage systems. Excavation shall extend a sufficient distance from walls and footings to allow for placing and removal of forms. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory material encountered below the grades shown shall be removed as directed and replaced with satisfactory material; and payment will be made in conformance with the CHANGES clause of the CONTRACT CLAUSES. Satisfactory material removed below the depths indicated, without specific direction of the Contracting Officer, shall be replaced, at no additional cost to the Government, with satisfactory materials to the indicated excavation grade; except that concrete footings shall be increased in thickness to the bottom of the overdepth excavations and over-break in rock excavation. Satisfactory material shall be placed and compacted as specified in paragraph FILLING AND BACKFILLING. Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done under the direction of the Contracting Officer.

3.3 DRAINAGE AND DEWATERING

3.3.1 Drainage

Surface water shall be directed away from excavation and construction sites to prevent erosion and undermining of foundations. Diversion ditches, dikes and grading shall be provided and maintained as necessary during construction. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained. **Drainage shall comply with requirements of Contract Specification Section 01431 ENVIRONMENTAL PROTECTION.**

3.4 CLASSIFICATION OF EXCAVATION

Excavation will be unclassified regardless of the nature of material encountered.

3.5 UTILITY AND DRAIN TRENCHES

Trenches for underground utilities systems and drain lines shall be excavated to the required alignments and depths. The bottoms of trenches

shall be graded to secure the required slope and shall be tamped if necessary to provide a firm pipe bed. Recesses shall be excavated to accommodate bells and joints so that pipe will be uniformly supported for the entire length. Rock, where encountered, shall be excavated to a depth of at least 6 inches below the bottom of the pipe, and the overdepth shall be backfilled with satisfactory material placed and compacted in conformance with paragraph FILLING AND BACKFILLING.

3.6 EXCAVATED MATERIALS

Satisfactory excavated material required for fill or backfill shall be placed in the proper section of the permanent work required under this section or shall be separately stockpiled if it cannot be readily placed. Satisfactory material in excess of that required for the permanent work and all unsatisfactory material shall be disposed of as determined by the Contracting Officer.

3.7 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials as directed by the Contracting Officer. The surface shall be scarified to a depth of 6 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 6 inches, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Minimum subgrade density shall be as specified in paragraph FILLING AND BACKFILLING.

3.8 FILLING AND BACKFILLING

Satisfactory materials shall be used in bringing fills and backfills to the lines and grades indicated and for replacing unsatisfactory materials. Satisfactory materials shall be placed in horizontal layers not exceeding 8 inches in loose thickness, or 6 inches when hand-operated compactors are used. After placing, each layer shall be plowed, disked, or otherwise broken up, moistened or aerated as necessary to a moisture content at least 3 percent above optimum, thoroughly mixed and compacted as specified. Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved, forms removed, and the excavation cleaned of trash and debris. Backfill shall be brought to indicated finish grade. Backfill shall not be placed in wet areas. Where pipe is coated or wrapped for protection against corrosion, the backfill material up to an elevation 2 feet above sewer lines and 1 foot above other utility lines shall be free from stones larger than 1 inch in any dimension. Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted in layers not more than 4

inches in compacted thickness with power-driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes or tanks to avoid damage to coatings, wrappings, or tanks. Backfill shall not be placed against foundation walls prior to 7 days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall. Each layer of fill and backfill shall be compacted to not less than 95 percent of maximum density, ASTM D 1557.

Approved compacted subgrades that are disturbed by the Contractor's operations or adverse weather shall be scarified and compacted as specified herein before to the required density prior to further construction thereon. Recompaction over underground utilities and heating lines shall be by hand tamping.

3.9 TESTING

Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government. Testing shall be performed by an approved commercial testing laboratory or may be performed by the Contractor subject to approval. Field in-place density shall be determined in accordance with ASTM D 1556, or ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted if necessary by the procedure described in ASTM D 2922, paragraph ADJUSTING CALIBRATION CURVE. ASTM D 2922 results in a wet unit weight of soil and when using this method ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 3017. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed by the Contracting Officer. ASTM D 2937 shall be used only for soft, fine-grained, cohesive soils. The following number of tests, if performed at the appropriate time, shall be the minimum acceptable for each type operation.

Copies of Calibration curves, results of calibration tests, and field and laboratory density tests shall be furnished to the Contracting Officer within 24 hours of conclusion of the tests.

3.9.1 In-Place Densities

In-place density and moisture content test results shall be included with the Contractor's daily construction quality control reports.

3.9.1.1 In-Place Density of Subgrades

One test per 1000 square foot or fraction thereof.

3.9.1.2 In-Place Density of Fills and Backfills

One test per 1000 square foot or fraction thereof of each lift for fill or backfill areas compacted by other than hand or hand-operated machines. The density for each lift of fill or backfill materials for trenches, pits, which are compacted with hand or hand-operated machines shall be tested as follows: One test per each area less than 20 square feet, or one test for each 10 linear foot of long narrow fills 10 feet or more in length. If ASTM D 2922 is used, in-place densities shall be checked by ASTM D 1556 as follows: One check for every (10) nuclear tests, or fraction thereof.

3.10 GRADING

Areas within 5 feet outside of each structure line shall be constructed true-to-grade, shaped to drain, and shall be maintained free of trash and debris until final inspection has been completed and the work has been accepted.

3.11 PROTECTION

Settlement or washing that occurs in graded, topsoiled, or backfilled areas prior to acceptance of the work, shall be repaired and grades reestablished to the required elevations and slopes.

Excavation surfaces or finish subgrades shall be protected from drying out and cracking by keeping the surface continuously moist until concrete pours or placement of base course and vapor barrier. If excavation surfaces become wet or muddy the surface shall be dried and recompacted or the wet material removed.

-- End of Section --

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DIVISION 03 - CONCRETE

SECTION 03300

CAST-IN-PLACE STRUCTURAL CONCRETE

-- End of Section Table of Contents --

SECTION 03300

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117/117R	(1990; Errata) Standard Tolerances for Concrete Construction and Materials
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214.3R	(1988) Simplified Version of the Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 301	(1996) Standard Specifications for Structural Concrete
ACI 305R	(1991) Hot Weather Concreting
ACI 318/318R	(1999) Building Code Requirements for Structural Concrete and Commentary

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(1998) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(19999a) Concrete Aggregates
ASTM C 39	(1996) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42	(1999) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 78	(1994) Flexural Strength of Concrete (Using Simple Beam With Third-Point Loading)
ASTM C 94	(1999) Ready-Mixed Concrete
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates

ASTM C 143	(1998) Slump of Hydraulic Cement Concrete
ASTM C 150	(1998a) Portland Cement
ASTM C 171	(1997a) Sheet Materials for Curing Concrete
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 192/C 192M	(1998) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 494	(1999) Chemical Admixtures for Concrete
ASTM C 878	(1995, Rev A) Standard Test Method for Restrained Expansion of Shrinkage - Compressive Concrete
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 940	(1998a) Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM C 1017	(1998) Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C 1059	(1999) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(1999) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	(1999) Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM C 1116	(1995) Fiber-Reinforced Concrete and Shotcrete
ASTM D 75	(1987; R 1997) Sampling Aggregates
ASTM E 96	(1995) Water Vapor Transmission of Materials
ASTM E 1745	(1997) Standard Specification for Plastic Water Vapor Retarders Used in Contract with Soil or Granular Fill under Concrete Slabs

CORPS OF ENGINEERS (COE)

COE CRD-C 104	(1980) Method of Calculation of the

	Fineness Modulus of Aggregate
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1997) NIST Handbook 44: Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1996) Concrete Plant Standards
NRMCA TMMB 100	(1994) Truck Mixer Agitator and Front Discharge Concrete Carrier Standards
NRMCA QC 3	(1984) Quality Control Manual: Section 3, Plant Certifications Checklist: Certification of Ready Mixed Concrete Production Facilities

1.2 LUMP SUM CONTRACT

Under this type of contract concrete items will be paid for by lump sum and will not be measured. The work covered by these items consists of furnishing all concrete materials, reinforcement, miscellaneous embedded materials, and equipment, and performing all labor for the forming, manufacture, transporting, placing, finishing, curing, and protection of concrete in these structures.

1.3 SUBMITTALS

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-08 Statements

Mixture Proportions; GA.

The results of trial mixture design studies along with a statement giving the maximum nominal coarse aggregate size and the proportions of ingredients that will be used in the manufacture of each strength or class of concrete, at least 14 days prior to commencing concrete placing operations. Aggregate weights shall be based on the saturated surface dry condition. The statement shall be accompanied by test results from an approved independent commercial testing laboratory, showing that mixture design studies have been made with materials proposed for the project and that the proportions selected will produce concrete of the qualities indicated. No substitutions shall be made in the materials used in the mixture design studies without additional tests to show that the quality of the concrete is satisfactory.

SD-09 Reports

Testing and Inspection for Contractor Quality Control; GA.

Certified copies of laboratory test reports, including mill tests and all other test data, for portland cement, blended cement, pozzolan, ground granulated blast furnace slag, silica fume, aggregate, admixtures, and curing compound proposed for use on this project.

SD-13 Certificates

Qualifications; GA.

Written documentation for Contractor Quality Control personnel.

SD-14 Samples

Surface Retarder; FIO.

Surface retarder material with manufacturer's instructions for application in conjunction with air-water cutting.

1.4 QUALIFICATIONS

Contractor Quality Control personnel assigned to concrete construction shall be American Concrete Institute (ACI) Certified Workmen in one of the following grades or shall have written evidence of having completed similar qualification programs:

Concrete Field Testing Technician, Grade I
Concrete Laboratory Testing Technician, Grade I or II
Concrete Construction Inspector, Level II

Concrete Transportation Construction Inspector or
Reinforced Concrete Special Inspector, Jointly certified by American Concrete Institute (ACI), Building Official and Code Administrators International (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International (SBCCI).

The foreman or lead journeyman of the flatwork finishing crew shall have similar qualification for ACI Concrete Flatwork Technician/Finisher or equal, with written documentation.

1.5 FIELD TEST FLOOR SLAB

Field test slabs shall be constructed 3 months prior to beginning of work using the materials and procedures proposed for use on the job, to demonstrate the results to be attained. The quality and appearance of the test slab shall be subject to the approval of the Contracting Officer, and, if not judged satisfactory, additional test slabs shall be constructed until approval is attained. Formed or finished surfaces in the completed structure shall match the quality and appearance of the approved field example.

1.5.1 Test Floor Slab

The test floor slab shall be at least 4 feet by 5 feet and 6 inches thick.

A full length expansion joint shall be constructed at the center of the test floor slab. All materials used for the actual expansion joint shall be used in the test floor slab. The concrete used for the test floor slab shall contain all admixtures used for the actual concrete. The test floor slab can be constructed in Honolulu or in Kwajalein and shall be available to the Contracting Officer for inspection.

1.6 SPECIAL REQUIREMENTS

A pre-installation meeting with the Contracting Officer will be required at least 10 days prior to start of construction. The Contractor shall be responsible for calling the meeting; the Project Superintendent and active installation personnel shall be present.

1.7 GENERAL REQUIREMENTS

1.7.1 Tolerances

Except as otherwise specified herein, tolerances for concrete batching, mixture properties, and construction as well as definition of terms and application practices shall be in accordance with ACI 117/117R. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing; when forms or shoring are used, the measurements shall be made prior to removal.

1.7.1.1 Floors

For the purpose of this Section the following terminology correlation between ACI 117/117R and this Section shall apply:

Floor Profile Quality Classification From ACI 117/117R	This Section
Conventional Bullfloated	Same
Conventional Straightedged	Same
Flat	Float Finish or Trowel Finish
Very Flat	Same. Use only with F-system

Levelness tolerance shall apply where design requires floors to be sloped to drains or sloped for other reasons.

1.7.1.2 Floors by the Straightedge System

The flatness of the floors shall be carefully controlled and the tolerances shall be measured by the straightedge system as specified in paragraph 4.5.7 of ACI 117/117R, using a 5 foot and adjusted for slopes to drain, straightedge and adjusted for slopes to drain, within 72 hours after floor slab installation and before shores and/or forms are removed. The listed tolerances shall be met at any and every location at which the straightedge can be placed.

Bullfloated	1/2 inches
Straightedged	5/16 inches
Float Finish	1/4 inches
Trowel Finish	3/16 inches

1.7.2 Strength Requirements and w/c Ratio

1.7.2.1 Strength Requirements

Specified compressive strength (f'c) shall be as follows:

COMPRESSIVE STRENGTH	STRUCTURE OR PORTION OF STRUCTURE
4000 psi at 28 days	All

Compressive strength shall be determined in accordance with ASTM C 39.

a. Evaluation of Concrete Compressive Strength. Compressive strength specimens (6 by 12 inch cylinders) shall be fabricated by the Contractor and laboratory cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 500 psi. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

b. Investigation of Low-Strength Compressive Test Results. When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 500 psi or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the strength of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement. Non-destructive tests (tests other than test cylinders or cores) shall not be used as a basis for acceptance or rejection. The Contractor shall perform the coring and repair the holes. Cores will be tested by the Government.

c. Load Tests. If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318/318R. Concrete work evaluated by structural analysis or by results of a load test as being understrength shall be corrected in a manner satisfactory to the Contracting Officer. All investigations, testing, load tests, and correction of deficiencies shall be performed by and at the expense of the Contractor and must be approved by the Contracting Officer, except that if all concrete is found to be in compliance with the drawings and specifications, the cost of investigations, testing, and load tests will be at the

expense of the Government.

1.7.2.2 Water-Cement Ratio

Maximum water-cement ratio (w/c) for normal weight concrete shall be as follows:

WATER-CEMENT RATIO, BY WEIGHT	STRUCTURE OR PORTION OF STRUCTURE
0.45	All

These w/c's may cause higher strengths than that required above for compressive or flexural strength. The maximum w/c required will be the equivalent w/c as determined by conversion from the weight ratio of water to cement plus pozzolan, by the weight equivalency method as described in ACI 211.1.

1.7.3 Air Entrainment

Air Entrainment shall be required.

1.7.4 Slump

Slump of the concrete, as delivered to the point of placement into the forms, shall be within the following limits. Slump shall be determined in accordance with ASTM C 143.

Structural Element	Slump	
	Minimum	Maximum
Foundation walls, substructure walls, footings, slabs	5 in.	6 in.

When use of a plasticizing admixture conforming to ASTM C 1017 or when a Type F or G high range water reducing admixture conforming to ASTM C 494 is permitted to increase the slump of concrete, concrete shall have a slump of 2 to 4 inches before the admixture is added and a maximum slump of 8 inches at the point of delivery after the admixture is added.

1.7.5 Concrete Temperature

The temperature of the concrete as delivered shall not exceed 90 degrees F. Concrete for the main water tank floor shall be placed at night between the hours of 08:00 pm and 06:00 AM.

1.7.6 Size of Coarse Aggregate

The largest feasible nominal maximum size aggregate (NMSA) specified in paragraph AGGREGATES shall be used in each placement. However, nominal maximum size of aggregate shall not exceed any of the following: three-fourths of the minimum cover for reinforcing bars, three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.

1.7.7 Special Properties and Products

Concrete may contain admixtures other than air entraining agents, such as water reducers, superplasticizers, or set retarding agents to provide special properties to the concrete, if specified or approved. Any of these materials to be used on the project shall be used in the mix design studies. Admixture manufacturer shall provide written document showing compatibility of all materials.

1.7.8 Technical Service for Specialized Concrete

The services of a factory trained technical representative shall be obtained to oversee proportioning, batching, mixing, placing, consolidating, and finishing of concrete with HWWR admixture. A factory trained technical representative shall be present on site for the High-Range Water Reducer (HRWR) admixture. The technical representative shall be on the job full time until the Contracting Officer is satisfied that field controls indicate concrete of specified quality is furnished and that the Contractor's crews are capable of continued satisfactory work. The technical representative shall be available for consultation with, and advice to, Government forces.

1.8 MIXTURE PROPORTIONS

Concrete shall be composed of portland cement, other cementitious and pozzolanic materials as specified, aggregates, water and admixtures as specified.

1.8.1 Proportioning Studies for Normal Weight Concrete

Trial design batches, mixture proportioning studies, and testing requirements for various classes and types of concrete specified shall be the responsibility of the Contractor. Except as specified for flexural strength concrete, mixture proportions shall be based on compressive strength as determined by test specimens fabricated in accordance with ASTM C 192/C 192M and tested in accordance with ASTM C 39. Samples of all materials used in mixture proportioning studies shall be representative of those proposed for use in the project and shall be accompanied by the manufacturer's or producer's test reports indicating compliance with these specifications. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project. The maximum water-cement ratios required in subparagraph Water-Cement Ratio. Laboratory trial mixtures shall be designed for maximum permitted slump and air content. Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for any conveying or placing method proposed which requires special properties and for concrete to be placed in unusually difficult placing locations. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance withASTM C 192/C 192M. They shall be tested at 7 and 28 days in accordance with ASTM C 39. From these test results, a curve shall be plotted showing the

relationship between water-cement ratio and strength for each set of trial mix studies. In addition, a curve shall be plotted showing the relationship between 7 day and 28 day strengths. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

1.8.2 Average Compressive Strength Required for Mixtures

The mixture proportions selected during mixture design studies shall produce a required average compressive strength (f'cr) exceeding the specified compressive strength (f'c) by the amount indicated below. This required average compressive strength, f'cr, will not be a required acceptance criteria during concrete production. However, whenever the daily average compressive strength at 28 days drops below f'cr during concrete production, or daily average 7-day strength drops below a strength correlated with the 28-day f'cr, the mixture shall be adjusted, as approved, to bring the daily average back up to f'cr. During production, the required f'cr shall be adjusted, as appropriate, based on the standard deviation being attained on the job.

1.8.2.1 Computations from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214.3R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected; shall represent concrete produced to meet a specified strength or strengths (f'c) within 1,000 psi of that specified for proposed work; and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days. Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

f'cr = f'c + 1.34S where units are in psi

f'cr = f'c + 2.33S - 500 where units are in psi

Where S = standard deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

1.8.2.2 Computations without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required

average strength f'cr shall be determined as follows:

a. If the specified compressive strength f'c is less than 3,000 psi,

f'cr = f'c + 1000 psi

b. If the specified compressive strength f'c is 3,000 to 5,000 psi,

f'cr = f'c + 1,200 psi

c. If the specified compressive strength f'c is over 5,000 psi,

f'cr = f'c + 1,400 psi

1.9 STORAGE OF MATERIALS

Cement and other cementitious materials shall be stored in weathertight buildings, bins, or silos which will exclude moisture and contaminants and keep each material completely separated. Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of aggregates. Aggregate shall not be stored directly on ground unless a sacrificial layer is left undisturbed. Reinforcing bars and accessories shall be stored above the ground on platforms, skids or other supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration. Admixtures which have been in storage at the project site for longer than 6 months or which have been subjected to freezing shall not be used unless retested and proven to meet the specified requirements. Materials shall be capable of being accurately identified after bundles or containers are opened.

1.10 GOVERNMENT ASSURANCE INSPECTION AND TESTING

Day-to day inspection and testing shall be the responsibility of the Contractor Quality Control (CQC) staff. However, representatives of the Contracting Officer can and will inspect construction as considered appropriate and will monitor operations of the Contractor's CQC staff. Government inspection or testing will not relieve the Contractor of any of his CQC responsibilities.

1.10.1 Materials

The Government will sample and test aggregates, cementitious materials, other materials, and concrete to determine compliance with the specifications as considered appropriate. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Other materials will be sampled from storage at the jobsite or from other locations as considered appropriate. Samples may be placed in storage for later testing when appropriate.

1.10.2 Fresh Concrete

Fresh concrete will be sampled as delivered in accordance with ASTM C 172 and tested in accordance with these specifications, as considered necessary.

1.10.3 Hardened Concrete

Tests on hardened concrete will be performed by the Government when such tests are considered necessary.

1.10.4 Inspection

Concrete operations may be tested and inspected by the Government as the project progresses. Failure to detect defective work or material will not prevent rejection later when a defect is discovered nor will it obligate the Government for final acceptance.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

Cementitious Materials shall be portland cement or portland-pozzolan and shall conform to appropriate specifications listed below.

2.1.1 Portland Cement

ASTM C 150, type II including false set requirements.

2.2 AGGREGATES

Aggregates shall conform to the following.

2.2.1 Fine Aggregate

Fine aggregate shall conform to the quality and gradation requirements of ASTM C 33.

2.2.2 Coarse Aggregate

Coarse aggregate shall conform to ASTM C 33, Class 5S, size designation 67.

2.3 CHEMICAL ADMIXTURES

Chemical admixtures, when required or permitted, shall conform to the appropriate specification listed. Admixtures shall be furnished in liquid form and of suitable concentration for easy, accurate control of dispensing.

2.3.1 Air-Entraining Admixture

Air-Entraining Admixture shall not be used.

2.3.2 Water-Reducing or Retarding Admixture

ASTM C 494, Type A, B, or D, except that the 6-month and 1-year compressive and flexural strength tests are waived.

2.3.3 High-Range Water Reducer (HRWR)

Eucon 37, Euclid chemical company or approved equal IAW ASTM C 494, Type F or G, except that the 6-month and 1-year strength requirements are waived.

2.3.4 Evaporation Retarder

Eucobar , Euclid Chemical Company, or approved equal.

2.3.5 Delete

2.3.6 Shrinkage Reducing Admixture

Shrinkage Reducing Admixture shall be Eclipse Shrinkage Reducing Admixture, by Grace Construction Products, or approved equal. Approved equal product shall be capable of 25% minimum reduction of ultimate drying shrinkage and shall be NSF approved for potable water tanks. Maximum reduction of specified 28 day concrete compressive strength shall be 15% (600 psi) to 3400 psi. The admixture shall be formulated and applied in accordance with the manufacturer's recommendations.

2.4 CURING MATERIALS

2.4.1 Impervious-Sheet

Impervious-sheet materials shall conform to ASTM C 171, type optional, except, that polyethylene sheet shall not be used.

2.4.2 Membrane-Forming Compound

Membrane-Forming curing compound shall not be used.

2.4.3 Burlap and Cotton Mat

Burlap and cotton mat shall not be used.

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water may be used if it meets the requirements of COE CRD-C 400.

2.6 NONSHRINK GROUT

Nonshrink grout shall conform to ASTM C 1107, and shall be a commercial formulation suitable for the proposed application.

2.7 LATEX MODIFIED NONSAG MORTAR

Latex Modified Nonsag Mortar for Vertical Concrete Surface Repairs shall be one of the following materials (or approved equal)

Vertical Supreme, Euclid Chemical Company
Thorite Rapid Vertical, Bonded Manufacturing Company
Polyfast, Dayton Superior Company
Tamms Speed Crete

Approved equal material shall be latex modified nonsag cement based mortar suitable for vertical application without forming, having a 7 day compressive strength of 5000 psi and flexural strength of 650 psi. Surface preparation shall consist of sandblasting, and mechanical scarifying of the entire surface on which material is to be placed.

2.8 LATEX BONDING AGENT

Latex agents for bonding fresh to hardened concrete shall conform to ASTM C 1059.

2.9 EPOXY RESIN

Epoxy resins for use in repairs shall conform to ASTM C 881, Type V. Grade and Class as appropriate for application.

2.10 VAPOR BARRIER

Vapor barrier material shall have the following properties:

Minimum 15-mil tick polyolefin geomembrane
Manufactured with ISO certified virgin resins.
Water Vapor Retarder ASTM E 1745 meets or exceeds Class B requirements with following modification;
Permeance Rating ASTM E 96 not exceeding 0.02 Perms

2.11 JOINT MATERIALS

2.11.1 Joint Fillers, Sealers, and Waterstops

Materials for expansion joints and waterstops shall be in accordance with Section 03150 EXPANSION JOINTS, CONTRACTION JOINTS and joint sealants for expansion joints.

2.12 SYNTHETIC FIBERS FOR REINFORCING

Concrete shall contain synthetic fibers conforming to ASTM C 1116, Type III, Synthetic Fiber 7.5 lbs per cy. Fibers shall be 100 percent virgin polypropylene fibrillated fibers containing no reprocessed olefin materials. Fibers shall have a specific gravity of 0.9, a minimum tensile strength of 70 ksi graded per manufacturer, and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement.

2.13 Evaporative Retarder

Evaporative Retarder shall be spayed over the fresh concrete surface immediately after bullfloating of the concrete floor slab. The evaporative retarder shall be Eucobar, by Euclid Chemical Company or approved equal. Spray equipment, mixing and application rate, installation shall be per manufacturers instructions. The evaporative retarder shall be used only to prevent rapid evaporation of the concrete slab moisture and shall not be used as a finishing aid.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

Before commencing concrete placement, the following shall be performed. Surfaces to receive concrete shall be clean and free from mastic. Forms shall be in place, cleaned, coated, and adequately supported. Reinforcing steel shall be in place, cleaned, tied, and adequately supported, in accordance with Section 03200 CONCRETE REINFORCEMENT. Transporting and conveying equipment shall be in-place, ready for use, clean, and free of hardened concrete and foreign material. Equipment for consolidating concrete shall be at the placing site and in proper working order. Equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the placing site, in proper working condition and in sufficient amount for the entire placement. When hot, windy conditions during concreting appear probable, equipment and material

shall be at the placing site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.1 Foundations

3.1.1.1 Concrete on Earth Foundations

Earth (subgrade, base, or subbase courses) surfaces upon which concrete is to be placed shall be clean, damp, and free from debris, and standing or running water. Prior to placement of concrete, the foundation shall be well drained and shall be satisfactorily graded and uniformly compacted.

3.1.2 Preparation of Previously Placed Concrete

Concrete surfaces to which other concrete is to be bonded shall be abraded in an approved manner that will expose sound aggregate uniformly without damaging the concrete. Laitance and loose particles shall be removed. Apply epoxy bonding agent immediately prior to placing new concrete.

3.2 CONCRETE PRODUCTION

3.2.1 Portable, Batching, Mixing, and Transporting Concrete

All concrete shall be batched after sunset and before sunrise. Concrete shall either be batched and mixed onsite by on-site batch plant and transpoiled accordance with ASTM C 94. Concrete truck mixers shall not be used. Concrete shall be batched and mixed onsite, or close to onsite, and shall conform to the following subparagraphs.

3.2.1.1 General

The batching plant shall be located on site in the general area approved by the Contracting Officer. The batching, mixing and placing system shall have a capacity of at least 75 cubic yards per hour. The batching plant shall conform to the requirements of NRMCA CPMB 100 and as specified; however, rating plates attached to batch plant equipment are not required.

3.2.1.2 Batching Equipment

The batching controls shall be semiautomatic or automatic, as defined in NRMCA CPMB 100. A semiautomatic batching system shall be provided with interlocks such that the discharge device cannot be actuated until the indicated material is within the applicable tolerance. The batching system shall be equipped with accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. The weight of water and admixtures shall be recorded if batched by weight. Separate bins or compartments shall be provided for each size group of aggregate and type of cementitious material, to prevent intermingling at any time. Aggregates shall be weighed either in separate weigh batchers with individual scales or, provided the smallest size is batched first, cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cementitious material. If both portland cement and other cementitious material are used, they may be batched cumulatively, provided that the portland cement is batched first, except that silica fume shall always be batched separately. Water may be measured by weight or volume. Water shall not be weighed or measured cumulatively with another ingredient. Filling and discharging valves for the water metering or batching system shall be so interlocked that the discharge valve cannot be opened before

the filling valve is fully closed. Piping for water and for admixtures shall be free from leaks and shall be properly valved to prevent backflow or siphoning. Admixtures shall be furnished as a liquid of suitable concentration for easy control of dispensing. An adjustable, accurate, mechanical device for measuring and dispensing each admixture shall be provided. Each admixture dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and individually discharged automatically in a manner to obtain uniform distribution throughout the water as it is added to the batch in the specified mixing period. When use of truck mixers makes this requirement impractical, the admixture dispensers shall be interlocked with the sand batchers. Different admixtures shall not be combined prior to introduction in water and shall not be allowed to intermingle until in contact with the cement. Admixture dispensers shall have suitable devices to detect and indicate flow during dispensing or have a means for visual observation. The plant shall be arranged so as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of aggregates from each bin or compartment, and for sampling and calibrating the dispensing of cementitious material, water, and admixtures. Filling ports for cementitious materials bins or silos shall be clearly marked with a permanent sign stating the contents.

3.2.1.3 Scales

The weighing equipment shall conform to the applicable requirements of CPMB Concrete Plant Standard, and of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. The tests shall be made at the specified frequency in the presence of a Government inspector. The weighing equipment shall be arranged so that the plant operator can conveniently observe all dials or indicators.

3.2.1.4 Portable Batching Tolerances

(A) Tolerances with Weighing Equipment

MATERIAL	PERCENT OF REQUIRED WEIGHT
Cementitious materials	0 to plus 2
Aggregate	plus or minus 2
Water	plus or minus 1
Chemical admixture	0 to plus 6

(B) Tolerances with Volumetric Equipment

For volumetric batching equipment used for water and admixtures, the following tolerances shall apply to the required volume of material being batched:

MATERIAL	PERCENT OF REQUIRED MATERIAL
Water:	plus or minus 1 percent

MATERIAL	PERCENT OF REQUIRED MATERIAL
Chemical admixtures:	0 to plus 6 percent

3.2.1.5 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched.

3.2.1.6 Concrete Mixers

Mixers shall be stationary mixers. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.2.1.7 Stationary Mixers

Concrete plant mixers shall be drum-type mixers of tilting, nontilting, horizontal-shaft, or vertical-shaft type, or shall be pug mill type and shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the requirements in ASTM C 94 applicable to central-mixed concrete.

3.3 CONCRETE PRODUCTION, SMALL PROJECTS

Batch-type equipment shall be used for producing concrete. Ready-mixed concrete shall be batched, mixed, and transported in accordance with ASTM C 94, except as otherwise specified. Agitators, and nonagitating transporting units shall comply with NRMCA TMMB 100. Ready-mix plant equipment and facilities shall be certified in accordance with NRMCA QC 3. Approved batch tickets shall be furnished for each load of ready-mixed concrete. Site-mixed concrete shall be produced in accordance with ACI 301, and plant shall conform to NRMCA CPMB 100.

3.4 FIBER REINFORCED CONCRETE

Fiber reinforced concrete shall conform to ASTM C 1116 and as follows, using the fibers specified in PART 2. A minimum of 1.5 pounds of fibers per cubic yard of concrete shall be used. Fibers shall be added at the batch plant. Toughness indices shall meet requirements for performance level I of ASTM C 1116. The services of a qualified technical representative shall be provided to instruct the concrete supplier in proper batching and mixing of materials to be provided.

3.5 TRANSPORTING CONCRETE TO PROJECT SITE

Concrete shall be transported to the placing site in agitators, nonagitating transporting equipment conforming to NRMCA TMMB 100 or by approved pumping equipment or conveyors.

3.6 CONVEYING CONCRETE ON SITE

Concrete shall be conveyed from mixer or transporting unit to forms as rapidly as possible and within the time interval specified by methods which will prevent segregation or loss of ingredients using following equipment. Conveying equipment shall be cleaned before each placement.

3.6.1 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at least 5 times the nominal maximum-size aggregate, and the area of the gate opening shall not be less than 2 square feet.The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than 2 cubic yardsshall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

3.6.2 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and shall have conical-shaped discharge features. The transfer hopper shall be equipped with a hydraulically operated gate and with a means of external vibration to effect complete discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

3.6.3 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes normally attached to this equipment by the manufacturer may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete.

3.6.4 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means, such as discharge baffle or hopper , for preventing segregation of the concrete at the transfer points and the point of placing. Belt conveyors shall be constructed such that the idler spacing shall not exceed 36 inches. The belt speed shall be a minimum of 300 feet per minute and a maximum of 750 feet per minute. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant truck that is long enough to extend through the reinforcing bars.

3.6.5 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure type; pneumatic placing equipment shall not be used. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least 3 times the nominal maximum-size coarse aggregate in the concrete

mixture to be pumped but not less than 4 inches. Aluminum pipe shall not be used.

3.7 PLACING CONCRETE

Mixed concrete shall be discharged within 1-1/2 hours or before the mixer drum has revolved 300 revolutions, whichever comes first after the introduction of the mixing water to the cement and aggregates. When the concrete temperature exceeds 85 degrees F, the time shall be reduced to 45 minutes. Concrete shall be placed within 15 minutes after it has been discharged from the transporting unit. Concrete shall be handled from mixer or transporting unit to forms in a continuous manner until the approved unit of operation is completed. Adequate scaffolding, ramps and walkways shall be provided so that personnel and equipment are not supported by in-place reinforcement. Placing will not be permitted when the sun, heat, wind, or limitations of facilities furnished by the Contractor prevent proper consolidation, finishing and curing. Sufficient placing capacity shall be provided so that concrete can be kept free of cold joints.

3.7.1 Depositing Concrete

Concrete shall be deposited as close as possible to its final position in the forms, and there shall be no vertical drop greater than 5 feet except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively consolidated in horizontal layers not more than 12 inches thick, except that all slabs shall be placed in a single layer. Concrete to receive other construction shall be screeded to the proper level. Concrete shall be deposited continuously in one layer or in layers so that fresh concrete is deposited on in-place concrete that is still plastic. Fresh concrete shall not be deposited on concrete that has hardened sufficiently to cause formation of seams or planes of weakness within the section. Concrete that has surface dried, partially hardened, or contains foreign material shall not be used. When temporary spreaders are used in the forms, the spreaders shall be removed as their service becomes unnecessary. Concrete shall not be placed in slabs over columns and walls until concrete in columns and walls has been in-place at least two hours or until the concrete begins to lose its plasticity. Concrete for beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as concrete for adjoining slabs.

3.7.2 Consolidation

Immediately after placing, each layer of concrete shall be consolidated by internal vibrators, except for slabs 4 inches thick or less. The vibrators shall at all times be adequate in effectiveness and number to properly consolidate the concrete; a spare vibrator shall be kept at the jobsite during all concrete placing operations. The vibrators shall have a frequency of not less than 10,000 vibrations per minute, an amplitude of at least 0.025 inch, and the head diameter shall be appropriate for the structural member and the concrete mixture being placed. Vibrators shall be inserted vertically at uniform spacing over the area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator so that the area being vibrated will overlap the adjacent just-vibrated area by a reasonable amount. The vibrator shall penetrate rapidly to the bottom of the layer and at least 6 inches into the preceding layer if there is such. Vibrator shall be held stationary until the concrete is consolidated and then vertically withdrawn slowly while

operating. Form vibrators shall not be used unless specifically approved and unless forms are constructed to withstand their use. Vibrators shall not be used to move concrete within the forms. Slabs 4 inches and less in thickness shall be consolidated by properly designed vibrating screeds or other approved technique. Excessive vibration of lightweight concrete resulting in segration or flotation of coarse aggregate shall be prevented. Frequency and amplitude of vibrators shall be determined in accordance with COE CRD-C 521. Grate tampers ("jitterbugs") shall not be used.

3.7.3 Hot Weather Requirements

Concrete shall be place at night. When the ambient temperature during concrete placing is expected to exceed 85 degrees F, the concrete shall be placed and finished with procedures previously submitted and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C 1064/C 1064M. Cooling of the mixing water or aggregates or placing concrete in the cooler part of the day may be required to obtain an adequate placing temperature. A retarder may be used, as approved, to facilitate placing and finishing. Steel forms and reinforcements shall be cooled as approved prior to concrete placement when steel temperatures are greater than 120 degrees F. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature Degrees
Greater than 60	90 F
40-60	85 F
Less than 40	80 F

3.7.4 Prevention of Plastic Shrinkage Cracking

During hot weather with low humidity, and particularly with appreciable wind, the Contractor shall be alert to the tendency for plastic shrinkage cracks to develop and shall institute measures to prevent this. Particular care shall be taken if plastic shrinkage cracking is potentially imminent and especially if it has developed during a previous placement. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 2.1.5 of ACI 305R. In addition the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, sprinkling, ponding or wet covering. Plastic shrinkage cracks that occur shall be filled by injection of epoxy resin as directed, after the concrete hardens. Plastic shrinkage cracks shall never be troweled over or filled with slurry.

3.8 JOINTS

Joints shall be located and constructed only as indicated or approved.

3.8.1 Construction Joints

Construction joints are not permitted.

3.8.2 Contraction Joints in Slabs on Grade

There are no contraction joints for the tank slab.

3.8.3 Expansion Joints

Installation of expansion joints and sealing of these joints shall conform to the requirements of Section 03150 EXPANSION JOINTS.

3.8.4 Dowels and Tie Bars

Dowels and tie bars shall be installed at the locations shown on the drawings and to the details shown, using materials and procedures specified in Section 03200 CONCRETE REINFORCEMENT and herein. Conventional smooth "paving" dowels shall be installed in slabs using approved methods to hold the dowel in place during concreting within a maximum alignment tolerance of 1/8 inch in 12 inches. "Structural" type deformed bar dowels, or tie bars, shall be installed to meet the specified tolerances. Care shall be taken during placing adjacent to and around dowels and tie bars to ensure there is no displacement of the dowel or tie bar and that the concrete completely embeds the dowel or tie bar and is thoroughly consolidated.

3.9 FINISHING FORMED SURFACES

Finishing of formed surfaces shall be as specified herein. Unless another type of architectural or special finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired. Unless painting of surfaces is required, uniform color of the concrete shall be maintained by use of only one mixture without changes in materials or proportions for any structure or portion of structure that requires a Class A or B finish. Except for major defects, as defined hereinafter, surface defects shall be repaired as specified herein within 24 hours after forms are removed. Repairs of the so-called "plaster-type" will not be permitted in any location. Tolerances of formed surfaces shall conform to the requirements of ACI 117/117R. These tolerances apply to the finished concrete surface, not to the forms themselves; forms shall be set true to line and grade. Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter shall be repaired as specified in paragraph Damp-Pack Mortar Repair. Defects whose surface diameter is greater than their depth shall be repaired as specified in paragraph Repair of Major Defects. Repairs shall be finished flush with adjacent surfaces and with the same surface texture. The cement used for all repairs shall be a blend of job cement with white cement proportioned so that the final color after curing and aging will be the same as the adjacent concrete. Concrete with excessive honeycomb, or other defects which affect the strength of the member, will be rejected. Repairs shall be demonstrated to be acceptable and free from cracks or loose or drummy areas at the completion of the contract and, for Class A and B Finishes, shall be inconspicuous. Repairs not meeting these requirements will be rejected and shall be replaced.

3.9.1 Class B Finish

Class B finish is required to all formed concrete surfaces. Fins, ravelings, and loose material shall be removed, all surface defects over 1/2 inch in diameter or more than 1/2 inch deep, shall be repaired and, except as otherwise indicated. Defects more than 1/2 inch in diameter shall be cut back to sound concrete, but in all cases at least 1 inch deep.

The Contractor shall prepare a sample panel for approval (as specified in PART 1) before commencing repair, showing that the surface texture and color match will be attained.

3.9.2 Smooth Finish

After other concrete construction is complete in each overall separate contiguous area of the structure, smooth finish shall be applied to the areas indicated on the drawings. A mortar mix consisting of one part portland cement and two parts well-graded sand passing a No. 30 sieve, with water added to give the consistency of thick paint, shall be used. Where the finished surface will not receive other applied surface, white cement shall be used to replace part of the job cement to produce an approved color, which shall be uniform throughout the surfaces of the structure. After the surface has been thoroughly wetted and allowed to approach surface dryness, the mortar shall be vigorously applied to the area by clean burlap pads or by cork or wood-floating, to completely fill all surface voids. Excess grout shall be scraped off with a trowel. As soon as it can be accomplished without pulling the mortar from the voids, the area shall be rubbed with burlap pads having on their surface the same sand-cement mix specified above but without any mixing water, until all of the visible grout film is removed. The burlap pads used for this operation shall be stretched tightly around a board to prevent dishing the mortar in the voids. The finish of any area shall be completed in the same day, and the limits of a finished area shall be made at natural breaks in the surface. The surface shall be continuously moist cured for 48 hours commencing immediately after finishing operations in each area. The temperature of the air adjacent to the surface shall be not less than 50 degrees F for 24 hours prior to, and 48 hours after, the application. In hot, dry weather the smooth finish shall be applied in shaded areas or at night, and shall never be applied when there is significant hot, dry wind.

3.10 REPAIRS

3.10.1 Damp-Pack Mortar Repair

Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter but not over 4 inches shall be repaired by the damp-pack mortar method. Form tie holes shall be reamed and other similar defects shall be cut out to sound concrete. The void shall then be thoroughly cleaned, thoroughly wetted, brush-coated with a thin coat of neat cement grout and filled with mortar. Mortar shall be a stiff mix of 1 part portland cement to 2 parts fine aggregate passing the No. 16 mesh sieve, and minimum amount of water. Only sufficient water shall be used to produce a mortar which, when used, will stick together on being molded into a ball by a slight pressure of the hands and will not exude water but will leave the hands damp. Mortar shall be mixed and allowed to stand for 30 to 45 minutes before use with remixing performed immediately prior to use. Mortar shall be thoroughly tamped in place in thin layers using a hammer and hardwood block. Holes passing entirely through walls shall be completely filled from the inside face by forcing mortar through to the outside face. All holes shall be packed full. Damp-pack repairs shall be moist cured for at least 48 hours.

3.10.2 Repair of Major Defects

Major defects will be considered to be those more than 1/2 inch deep or, for Class A and B finishes, more than 1/2 inch in diameter and, for Class C and D finishes, more than 2 inches in diameter. Also included are any

defects of any kind whose depth is over 4 inches or whose surface diameter is greater than their depth. Major defects shall be repaired as specified below.

3.10.2.1 Surface Application of Mortar Repair

Defective concrete shall be removed, and removal shall extend into completely sound concrete. Approved equipment and procedures which will not cause cracking or microcracking of the sound concrete shall be used. If reinforcement is encountered, concrete shall be removed so as to expose the reinforcement for at least 2 inches on all sides. All such defective areas greater than 12 square inchesshall be outlined by saw cuts at least 1 inch deep. Defective areas less than 12 square inches shall be outlined by a 1 inch deep cut with a core drill in lieu of sawing. All saw cuts shall be straight lines in a rectangular pattern in line with the formwork panels. After concrete removal, the surface shall be thoroughly cleaned by high pressure washing to remove all loose material. Surfaces shall be kept continually saturated for the first 12 of the 24 hours immediately before placing mortar and shall be damp but not wet at the time of commencing mortar placement. The Contractor, at his option, may use either hand-placed mortar or mortar placed with a mortar gun. If hand-placed mortar is used, the edges of the cut shall be perpendicular to the surface of the concrete. The prepared area shall be brush-coated with a thin coat of neat cement grout. The repair shall then be made using a stiff mortar, preshrunk by allowing the mixed mortar to stand for 30 to 45 minutes and then remixed, thoroughly tamped into place in thin layers. If hand-placed mortar is used, the Contractor shall test each repair area for drumminess by firm tapping with a hammer and shall inspect for cracks, both in the presence of the Contracting Officer's representative, immediately before completion of the contract, and shall replace any showing drumminess or cracking. If mortar placed with a mortar gun is used, the gun shall be a small compressed air-operated gun to which the mortar is slowly hand fed and which applies the mortar to the surface as a high-pressure stream, as approved. Repairs made using shotcrete equipment will not be accepted. The mortar used shall be the same mortar as specified for damp-pack mortar repair. If gun-placed mortar is used, the edges of the cut shall be beveled toward the center at a slope of 1:1. All surface applied mortar repairs shall be continuously moist cured for at least 7 days. Moist curing shall consist of several layers of saturated burlap applied to the surface immediately after placement is complete and covered with polyethylene sheeting, all held closely in place by a sheet of plywood or similar material rigidly braced against it. Burlap shall be kept continually wet.

3.10.2.2 Repair of Deep and Large Defects

Deep and large defects will be those that are more than 6 inches deep and also have an average diameter at the surface more than 18 inches or that are otherwise so identified by the Project Office. Such defects shall be repaired as specified herein or directed, except that defects which affect the strength of the structure shall not be repaired and that portion of the structure shall be completely removed and replaced. Deep and large defects shall be repaired by procedures approved in advance including forming and placing special concrete using applied pressure during hardening. Preparation of the repair area shall be as specified for surface application of mortar. In addition, the top edge (surface) of the repair area shall be sloped at approximately 20 degrees from the horizontal, upward toward the side from which concrete will be placed. The special concrete shall be a concrete mixture with low water content and low slump,

and shall be allowed to age 30 to 60 minutes before use. Concrete containing a specified expanding admixture may be used in lieu of the above mixture; the paste portion of such concrete mixture shall be designed to have an expansion between 2.0 and 4.0 percent when tested in accordance with ASTM C 940. A full width "chimney" shall be provided at the top of the form on the placing side to ensure filling to the top of the opening. A pressure cap shall be used on the concrete in the chimney with simultaneous tightening and revibrating the form during hardening to ensure a tight fit for the repair. The form shall be removed after 24 hours and immediately the chimney shall be carefully chipped away to avoid breaking concrete out of the repair; the surface of the repair concrete shall be dressed as required.

3.11 FINISHING UNFORMED SURFACES

The finish of all unformed surfaces shall meet the requirements of paragraph Tolerances in PART 1, when tested as specified herein.

3.11.1 General

In hot weather all requirements of paragraphs Hot Weather Requirements and Prevention of Plastic Shrinkage Cracking shall be met. Unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish, with additional finishing as specified below, and shall be true to the elevation shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings, properly consolidated, and left true and regular. Unless otherwise shown on the drawings, exterior surfaces shall be sloped for drainage, as directed. Where drains are provided, interior floors shall be evenly sloped to the drains. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or "jitterbugs" shall not be used for any surfaces. The dusting of surfaces with dry cement or other materials or the addition of any water during finishing shall not be permitted. If bleedwater is present prior to finishing, the excess water shall be carefully dragged off or removed by absorption with porous materials such as burlap. During finishing operations, extreme care shall be taken to prevent over finishing or working water into the surface; this can cause "crazing" (surface shrinkage cracks which appear after hardening) of the surface. Any slabs with surfaces which exhibit significant crazing shall be removed and replaced. During finishing operations, surfaces shall be checked with a 10 foot straightedge, applied in both directions at regular intervals while the concrete is still plastic, to detect high or low areas.

3.11.2 Rough Slab Finish

As a first finishing operation for unformed surfaces and as final finish for slabs to receive mortar setting beds, the surface shall receive a rough slab finish prepared as follows. The concrete shall be uniformly placed across the slab area, consolidated as previously specified, and then screeded with straightedge strikeoffs immediately after consolidation to bring the surface to the required finish level with no coarse aggregate visible. Side forms and screed rails shall be provided, rigidly supported, and set to exact line and grade. Allowable tolerances for finished surfaces apply only to the hardened concrete, not to forms or screed rails. Forms and screed rails shall be set true to line and grade. "Wet screeds" shall not be used.

3.11.3 Floated Finish

Slabs to receive more than a rough slab finish shall next be given a wood float finish. The screeding shall be followed immediately by darbying or bull floating before bleeding water is present, to bring the surface to a true, even plane. Then, after the concrete has stiffened so that it will withstand a man's weight without imprint of more than 1/4 inch and the water sheen has disappeared, it shall be floated to a true and even plane free of ridges. Floating shall be performed by use of suitable hand floats or power driven equipment. Sufficient pressure shall be used on the floats to bring a film of moisture to the surface. Hand floats shall be made of wood, magnesium, or aluminum. Lightweight concrete or concrete that exhibits stickiness shall be floated with a magnesium float. Care shall be taken to prevent over-finishing or incorporating water into the surface.

3.11.4 Troweled Finish

All tank floor slabs shall be given a trowel finish. After floating is complete and after the surface moisture has disappeared, unformed surfaces shall be steel-troweled to a smooth, even, dense finish, free from blemishes including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. Additional trowelings shall be performed, either by hand or machine until the surface has been troweled 4 times, with waiting period between each. Care shall be taken to prevent blistering and if such occurs, troweling shall immediately be stopped and operations and surfaces corrected. A final hard steel troweling shall be done by hand, with the trowel tipped, and using hard pressure, when the surface is at a point that the trowel will produce a ringing sound. The finished surface shall be thoroughly consolidated and shall be essentially free of trowel marks and be uniform in texture and appearance. The concrete mixture used for troweled finished areas shall be adjusted, if necessary, in order to provide sufficient fines (cementitious material and fine sand) to finish properly.

3.12 CURING AND PROTECTION

3.12.1 General

Concrete shall be cured by total immersion of water 60 days after concrete finishing.

3.12.2 Immersion Curing

Concrete slab for sump pit area slab shall be used with impetuous sheeting and continuous mist spraying. The main concrete slab shall be cured by. continuous immersed with 1 inches to 2 inches of potable water immediately after finishing the concrete slab for a period of 60 days.

3.13 SETTING BASE PLATES AND BEARING PLATES

3.13.1 Nonshrink Grout

Nonshrink grout shall be a ready-mixed material requiring only the addition of water. Water content shall be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.13.1.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified therein. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or machinery-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for completely retaining the grout on all sides and on top and shall be removed after the grout has set. The placed grout shall be carefully worked by rodding or other means to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 65 to 85 degrees F until after setting.

3.13.1.2 Treatment of Exposed Surfaces

For metal-oxidizing nonshrink grout, exposed surfaces shall be cut back 1 inch and immediately covered with a parge coat of mortar consisting of 1 part portland cement and 2-1/2 parts fine aggregate by weight, with sufficient water to make a plastic mixture. The parge coat shall have a smooth finish. For other mortars or grouts, exposed surfaces shall have a smooth-dense finish and be left untreated. Curing shall comply with paragraph CURING AND PROTECTION.

3.14 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

The Contractor shall perform the inspection and tests described below and, based upon the results of these inspections and tests, shall take the action required and shall submit specified reports. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease and the operation shall be corrected. The laboratory performing the tests shall be onsite and shall conform with ASTM C 1077. Materials may be subjected to check testing by the Government from samples obtained at the manufacturer, at transfer points, or at the project site. The Government will inspect the laboratory, equipment, and test procedures prior to start of concreting operations for conformance with ASTM C 1077.

3.14.1 Grading and Corrective Action

3.14.1.1 Fine Aggregate

At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall immediately reported to the Contracting Officer, concreting shall be stopped, and immediate steps taken to correct the grading.

3.14.1.2 Coarse Aggregate

At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of 5 tests are outside specification limits, the operation shall be considered out of control and shall be reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

3.14.2 Quality of Aggregates

Thirty days prior to the start of concrete placement, the Contractor shall perform all tests for aggregate quality required by ASTM C 33. In addition, after the start of concrete placement, the Contractor shall perform tests for aggregate quality at least every three months, and when the source of aggregate or aggregate quality changes. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

3.14.3 Scales, Batching and Recording

The accuracy of the scales shall be checked by test weights prior to start of concrete operations and at least once every three months. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors. Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. At the same time, the Contractor shall test and ensure that the devices for dispensing admixtures are operating properly and accurately. When either the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.14.4 Batch-Plant Control

The measurement of concrete materials including cementitious materials, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic yard, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic yard for each class of concrete batched during each day's plant operation.

3.14.5 Concrete Mixture

a. Air Content Testing. Air content tests shall be made when test specimens are fabricated. In addition, at least two tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Tests shall be made in accordance with ASTM C 878. Test results shall be plotted on control charts which shall at all times be readily available to the Government and shall be submitted weekly. Copies of the current control charts shall be kept in the field by testing crews and results plotted as tests are made. When a single test result reaches either the upper or lower action limit, a second test shall immediately be made. The results of the two tests shall be averaged and this average used as the air content of the batch to plot on both the air content and the control chart for range, and for determining need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate control chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from paragraph Air Entrainment. An upper warning limit and a lower warning limit line shall be set 1.0 percentage point above and below the average line, respectively. An upper action limit and a lower action limit line shall be set 1.5 percentage points above and below the average line, respectively. The range between each two consecutive tests shall be plotted on a secondary control chart for range where an upper warning limit is set at 2.0 percentage points and an upper action limit is set at 3.0 percentage points. Samples for air content may be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated air content. If the Contractor's materials or transportation methods cause air content loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer, and the air content at the mixer controlled as directed.

b. Air Content Corrective Action. Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the secondary control chart for range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted until the air content is under control. Additional air content tests shall be made when concreting is restarted.

c. Slump Testing. In addition to slump tests which shall be made when test specimens are fabricated, at least four slump tests shall be made on randomly selected batches in accordance with ASTM C 143 for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also,

additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Test results shall be plotted on control charts which shall at all times be readily available to the Government and shall be submitted weekly. Copies of the current control charts shall be kept in the field by testing crews and results plotted as tests are made. When a single slump test reaches or goes beyond either the upper or lower action limit, a second test shall immediately be made. The results of the two tests shall be averaged and this average used as the slump of the batch to plot on both the control charts for slump and the chart for range, and for determining need for any remedial action. Limits shall be set on separate control charts for slump for each type of mixture. The upper warning limit shall be set at 1/2 inch below the maximum allowable slump specified in paragraph Slump in PART 1 for each type of concrete and an upper action limit line and lower action limit line shall be set at the maximum and minimum allowable slumps, respectively, as specified in the same paragraph. The range between each consecutive slump test for each type of mixture shall be plotted on a single control chart for range on which an upper action limit is set at 2 inches. Samples for slump shall be taken at the mixer. However, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer, and the slump at the mixer controlled as directed.

d. Slump Corrective Action. Whenever points on the control charts for slump reach the upper warning limit, an adjustment shall immediately be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum w/c ratio specified, based on aggregates which are in a saturated surface dry condition. When a single slump reaches the upper or lower action limit, no further concrete shall be delivered to the placing site until proper adjustments have been made. Immediately after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, the concreting operation shall immediately be halted, and the Contractor shall take appropriate steps to bring the slump under control. Additional slump tests shall be made as directed.

e. Temperature. The temperature of the concrete shall be measured when compressive strength specimens are fabricated. Measurement shall be in accordance with ASTM C 1064/C 1064M. The temperature shall be reported along with the compressive strength data.

f. Strength Specimens. At least one set of test specimens shall be made, for compressive or flexural strength as appropriate, on each different concrete mixture placed during the day for each 500 cubic yards or portion thereof of that concrete mixture placed each day. Additional sets of test specimens shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. A truly

random (not haphazard) sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength per paragraph Strength Requirements in PART 1 shall consist of four specimens, two to be tested at 7 days and two at 28 days. Test specimens shall be molded and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39 for test cylinders and ASTM C 78 for test beams. Results of all strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength "tests", ("test" as defined in paragraph Strength Requirements in PART 1) moving average of last 3 "tests" for strength, and moving average for range for the last 3 "tests" for each mixture. The charts shall be similar to those found in ACI 214.3R.

3.14.6 Inspection Before Placing

Foundations, construction joints, forms, and embedded items shall be inspected by the Contractor in sufficient time prior to each concrete placement in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

3.14.7 Placing

The placing foreman shall supervise placing operations, shall determine that the correct quality of concrete or grout is placed in each location as specified and as directed by the Contracting Officer, and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume placed, and method of placement. The placing foreman shall not permit batching and placing to begin until it has been verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.14.8 Vibrators

The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head, and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing. Any vibrator not meeting the requirements of paragraph Consolidation, shall be immediately removed from service and repaired or replaced.

3.14.9 Curing Inspection

a. Moist Curing Inspections. At least once each shift, and not less than twice per day on both work and non-work days, an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist Curing Corrective Action. When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by 1 day.

c. Membrane Curing Inspection. No curing compound shall be applied until the Contractor has verified that the compound is properly mixed and ready for spraying. At the end of each operation, the Contractor shall estimate the quantity of compound used by measurement of the container and the area of concrete surface covered, shall compute the rate of coverage in square feet per gallon, and shall note whether or not coverage is uniform.

d. Membrane Curing Corrective Action. When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

e. Sheet Curing Inspection. At least once each shift and once per day on non-work days, an inspection shall be made of all areas being cured using impervious sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

f. Sheet Curing Corrective Action. When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by 1 day.

3.14.10 Mixer Uniformity

a. Stationary Mixers. Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every 75,000 cubic yards of concrete placed, whichever results in the shortest time interval, uniformity of concrete mixing shall be determined in accordance with ASTM C 94.

b. Truck Mixers. Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete mixing shall be determined in accordance with ASTM C 94. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory.

c. Mixer Uniformity Corrective Action. When a mixer fails to meet mixer uniformity requirements, either the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

3.14.11 Reports

All results of tests or inspections conducted shall be reported informally

as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

-- End of Section --

PROJECT TABLE OF CONTENTS

SUBMITTAL REGISTER

CONTRACT NO.
(Am-0002)

TITLE AND LOCATION
COLD STORAGE FACILITY, KWAJALEIN ATOLL, MARSHALL ISLANDS

CONTRACTOR

ACTIVITY NO	TRANSMITTAL NO	SPEC SECT	DESCRIPTION ITEM SUBMITTED	PARAGRAPH #	CLASSIFICATION	GOVT OR A/E REVWR	CONTRACTOR: SCHEDULE DATES			CONTRACTOR ACTION			APPROVING AUTHORITY					MAILED TO CONTR/ DATE RCD FRM APPR AUTH	REMARKS
							SUBMIT	APPROVAL NEEDED BY	MATERIAL NEEDED BY	ACTION CODE	DATE OF ACTION	DATE FWD TO APPR AUTH/ DATE RCD FROM CONTR	DATE FWD TO OTHER REVIEWER	DATE RCD FROM OTH REVIEWER	ACTION CODE	DATE OF ACTION		
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		01320	SD-01 Preconstruction Submittals																
			Preliminary Project Schedule	3.4.1	FIO														
			Initial Project Schedule	3.4.2	FIO														
			Periodic Schedule Updates	3.4.3	FIO														
			SD-06 Test Reports																
			Narrative Report	3.5.2	FIO														
			Schedule Reports	3.5.4	FIO														
			SD-07 Certificates																
			Qualifications	1.2	FIO														
		01430	SD-11 Closeout Submittals																
			Environmental Protection Plan		G	RE													
		01452	SD-07 Certificates																
			Special Inspector	1.3	G	ED													
			Quality Assurance Plan	1.4	G	ED													
		01572	SD-07 Certificates																
			Construction Waste Management	1.3	FIO														
			Plan																
		01780	SD-02 Shop Drawings																
			As-Built Drawings	1.2.1	FIO														
			SD-03 Product Data																
			As-Built Record of Equipment and	1.2.2	FIO														
			Materials																
			Warranty Management Plan	1.3.1	FIO														
			Warranty Tags	1.3.5	FIO														
			Final Clean-Up	1.6	FIO														
		01900	SD-01 Preconstruction Submittals																

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		01900	Progress Chart	1.2.1	G	RE												
			Bar Chart	1.2.1	G	RE												
			SD-02 Shop Drawings															
			As-Built Drawings	1.4	FIO													
			SD-03 Product Data															
			Equipment Data	1.2.2	FIO													
			Recovered Material Report	1.2.3	FIO													
			SD-07 Certificates															
			Products Containing Recovered	1.13	FIO													
			Materials															
			SD-08 Manufacturer’s Instructions															
			Inspection of Existing Conditions	1.2.4	G	RE												
			Dust Control	1.5	G	RE												
			Excavation/Trenching Clearance	1.2.5	G	RE												
			Condition of Contractor's	1.2.6	G	RE												
			Operation or Storage Area															
		02120	SD-03 Product Data															
			Notices of Non-Compliance and	1.2.1	FIO													
			Notices of Violation															
			On-site Hazardous Waste	3.1	G	RE												
			Management															
			SD-06 Test Reports															
			Recordkeeping	3.6	G	RE												
			Spill Response	3.7	G	RE												
			Exception Reports	3.6	G	RE												
			SD-07 Certificates															

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		02120	Qualifications	1.3	G	RE												
			EPA Off-Site Policy	3.2.2	G	RE												
			Management Plan	3.1.2	G	RE												
			Shipping Documents and	3.2.3	G	RE												
			Packagings Certification															
		02220	SD-08 Manufacturer’s Instructions															
			Work Plan	1.4	G	RE												
		02315	SD-09 Manufacturer’s Field															
			Reports															
			Testing		FIO													
		02316	SD-06 Test Reports															
			Field Density Tests	3.4.3	FIO													
			Testing of Backfill Materials	3.4.2	FIO													
		02510	SD-03 Product Data															
			Installation	3.1	FIO													
			Waste Water Disposal Method		FIO													
			Satisfactory Installation		FIO													
			SD-06 Test Reports															
			Bacteriological Disinfection	3.3.1	FIO													
		02531	SD-07 Certificates															
			Portland Cement	2.7.1	FIO													
			Joints	2.3	FIO													
		02532	SD-06 Test Reports															
			Hydrostatic Tests	3.2	G	RE												
		02630	SD-03 Product Data															
			Placing Pipe	3.3	FIO													

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		02630	SD-04 Samples															
			Pipe for Culverts and Storm	2.1	FIO													
			Drains															
			SD-07 Certificates															
			Resin Certification	2.1.2	FIO													
			Pipeline Testing	3.7	FIO													
			Hydrostatic Test on Watertight	2.4	FIO													
			Joints															
			Determination of Density	3.6.5	FIO													
			Frame and Cover for Gratings		FIO													
		02722	SD-03 Product Data															
			Plant, Equipment, and Tools	1.5	FIO													
			SD-06 Test Reports															
			Sampling and testing	1.4	FIO													
			Field Density Tests	1.4.2.4	G ED													
		02754	SD-03 Product Data															
			Equipment	1.6	FIO													
			Paving	3.4	FIO													
			Mixture Proportions	2.11	G ED													
		02763	SD-03 Product Data															
			Equipment		FIO													
			Composition Requirements		FIO													
			Qualifications		FIO													
			SD-06 Test Reports															
			Sampling and Testing		FIO													
			SD-07 Certificates															

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		02763	Volatile Organic Compound		FIO													
			(VOC)															
		02770	SD-03 Product Data															
			Concrete	2.1	FIO													
			SD-06 Test Reports															
			Field Quality Control	3.8	FIO													
		02821	SD-07 Certificates															
			Chain Link Fence	2.1.1	FIO													
		03100	SD-03 Product Data															
			Design	1.3	FIO													
			Form Materials	2.1	FIO													
			Form Releasing Agents	2.1.5	FIO													
		03151	SD-03 Product Data															
			Splicing Waterstops	2.2.2	G	RE												
			SD-04 Samples															
			Field Molded Sealants and Primer	2.1.2.1	FIO													
			Waterstops	2.1.3	FIO													
			SD-06 Test Reports															
			Premolded Expansion Joint Filler	2.1.1	FIO													
			Strips															
			Compression Seals and Lubricant	2.1.2.2	FIO													
			Metallic Waterstops	2.1.3.2	FIO													
		03200	SD-02 Shop Drawings															
			Reinforcement	3.1	G	RE												
			SD-03 Product Data															
			Welding	1.3	G	RE												

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		03200	SD-07 Certificates															
			Reinforcing Steel	2.1	G	RE												
		03230	SD-02 Shop Drawings															
			Installation Drawings	3.1.2	G	ED												
			SD-03 Product Data															
			Prestressing Method and	3.1.1	G	ED												
			Equipment															
			Materials Disposition Records	3.3	FIO													
			Prestressing Operations Records	3.1.7	FIO													
			SD-06 Test Reports															
			Stressing Tendons and	2.1	FIO													
			Accessories															
			SD-07 Certificates															
			Certification of Prestressing	1.3	FIO													
			Technicians															
		03300	SD-03 Product Data															
			Mixture Proportions	1.7	G	RE												
			SD-06 Test Reports															
			Testing and Inspection for	3.14	G	RE												
			Contractor Quality Control															
			SD-07 Certificates															
			Qualifications	1.3	FIO													
		03410	SD-02 Shop Drawings															
			Precast/Prestressed Units	1.3	G	AE												
			SD-03 Product Data															
			Precast/Prestressed Units	1.3	G	AE												

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		03410	SD-06 Test Reports															
			Tests	2.2	G	AE												
		03411	SD-02 Shop Drawings															
			Drawings of precast members	1.7.1	G	AE												
			SD-03 Product Data															
			inserts	2.2.7.1	FIO													
			Bearing pads	2.2.8	FIO													
			SD-05 Design Data															
			design calculations	1.7.2	G	AE												
			Concrete mix design	1.7.3	FIO													
			SD-06 Test Reports															
			Contractor-furnished mix design	2.1	FIO													
			SD-07 Certificates															
			Fabrication	2.3	FIO													
			SD-11 Closeout Submittals															
			batch ticket	1.7.4	FIO													
		03415	SD-02 Shop Drawings															
			Erection	3.9	G	AE												
			SD-03 Product Data															
			Erection Plan	3.9.5	G	AE												
			Design Calculations	1.3.1.3	G	AE												
			Concrete Mixture Proportions	2.2	G	AE												
			Construction Records	3.10	FIO													
			SD-04 Samples															
			Precast Panel	1.4	G	AE												
			SD-06 Test Reports															

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		03415	Materials	2.1	G	AE													
			Concrete	1.3.2.2	G	AE													
			SD-07 Certificates																
			Cement	2.1.1	G	AE													
			Air-Entraining Admixture	2.1.2.2	G	AE													
			Water-Reducing Admixture	2.1.2.2	G	AE													
			Accelerating Admixture		G	AE													
			Aggregates	2.1.2.1	G	AE													
			Air Content	1.3.2.3	FIO														
		04200	SD-02 Shop Drawings																
			Masonry Work		G	RE													
			SD-04 Samples																
			Concrete Masonry Units (CMU)	2.2	G	ED													
			Anchors, Ties, and Bar	2.6	G	ED													
			Positioners																
			Expansion-Joint Materials	2.10	G	ED													
			Joint Reinforcement	2.7	G	ED													
			SD-06 Test Reports																
			Field Testing of Mortar	3.15.1	G	RE													
			Field Testing of Grout	3.15.2	G	RE													
			Masonry Cement	2.4	G	RE													
			SD-07 Certificates																
			Concrete Masonry Units (CMU)	2.2	G	RE													
			Anchors, Ties, and Bar	2.6	G	RE													
			Positioners																
			Joint Reinforcement	2.7	G	RE													

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		04200	Reinforcing Steel Bars and Rods	2.8	G	RE												
			Masonry Cement	2.4	G	RE												
			Mortar Admixtures	2.4.1	G	RE												
			Grout Admixtures	2.5.1	G	RE												
		05090	SD-03 Product Data															
			Welding Procedure Qualifications	1.5	G	RE												
			Welder, Welding Operator, and	1.6	G	RE												
			Tacker Qualification															
			Inspector Qualification	1.7	G	RE												
			Previous Qualifications	1.5.1	G	RE												
			Prequalified Procedures	1.5.2	G	RE												
			SD-06 Test Reports															
			Quality Control	3.2	G	RE												
		05120	SD-02 Shop Drawings															
			Structural Connections	3.1.1	G	RE												
			SD-03 Product Data															
			Welding	3.2	G	RE												
			SD-04 Samples															
			Carbon Steel Bolts and Nuts	2.4	FIO													
			Nuts Dimensional Style	2.5	FIO													
			Washers	2.6	FIO													
			SD-07 Certificates															
			Mill Test Reports		G	RE												
			Welder Qualifications		G	RE												
			Welding Inspector	1.5	G	RE												
		05400	SD-02 Shop Drawings															

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		05400	Framing Components	2.1	FIO														
			SD-07 Certificates																
			Mill Certificates		FIO														
			Welds	3.2.1	FIO														
		05500	SD-02 Shop Drawings																
			Steel Pipe Bollards	3.1.1	FIO														
			Canopy Framing	3.1.2	FIO														
			Refrigerant Rack Frames	3.1.3	FIO														
			Stainless Steel Fixed Ladder	3.1.4	FIO														
			Stainless Steel Pipe Bicycle	3.1.5	FIO														
			Racks																
			Stainless Steel Mechanical	3.1.6	FIO														
			Enclosure Gate																
			Handhole Concrete Cover	3.1.7	FIO														
			Checker Plate at Door D-35	3.1.8	FIO														
		06100	SD-07 Certificates																
			Grading and Marking	2.1.1	FIO														
		06200	SD-02 Shop Drawings																
			Finish Carpentry	2.1	FIO														
			SD-03 Product Data																
			Laminated Plastic	2.1.6	FIO														
			SD-04 Samples																
			Laminated Plastic	2.1.6	FIO														
		06600	SD-02 Shop Drawings																
			FRP Shapes and Gratings	2.1.1	FIO														
			SD-03 Product Data																

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		06600	FRP Shapes and Gratings	2.1.1	FIO													
			SD-07 Certificates															
			FRP Shapes and Gratings	2.1.1	FIO													
		07132	SD-03 Product Data															
			Reinforcing Fabric	3.2.2	FIO													
			Protection Board	3.4.2	FIO													
			Applications	2.1.2	FIO													
			SD-07 Certificates															
			Materials	1.4	FIO													
		07212	SD-03 Product Data															
			Sound Attenuation Batt Insulation	2.1.1	FIO													
			Accessories	2.2	FIO													
			SD-08 Manufacturer’s Instructions															
			Sound Attenuation Batt Insulation	2.1.1	FIO													
		07220	SD-03 Product Data															
			Application of Insulation	3.6	FIO													
			Inspection	3.7	FIO													
			SD-07 Certificates															
			Insulation	2.2	FIO													
		07225	SD-02 Shop Drawings															
			Refrigerated Floor Insulation	1.2.1	FIO													
			SD-03 Product Data															
			Refrigerated Floor Insulation	1.2.1	FIO													
			SD-04 Samples															
			Insulation	2.1.1	FIO													
			Vapor Barrier	2.1.3	FIO													

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		07225	Slip Sheet	2.1.3	FIO														
		07240	SD-02 Shop Drawings																
			Drawings	2.2.1	FIO														
			Drawings	3.7.1	FIO														
			SD-03 Product Data																
			Exterior Insulation and Finish	1.3	FIO														
			System																
			Exterior Insulation and Finish	1.3	FIO														
			System																
			Water Vapor Transmission	1.5	FIO														
			Analysis																
			SD-04 Samples																
			Exterior Insulation and Finish	1.3	FIO														
			System																
			SD-06 Test Reports																
			Exterior Insulation and Finish	1.3	FIO														
			System																
			SD-07 Certificates																
			Qualifications	1.6.1	FIO														
			Qualifications	1.6.1	FIO														
			Third Party Inspection	3.9.1	FIO														
			Installer	3.2	FIO														
			Warranty	1.9	FIO														
			Insulation Board	2.2	FIO														
			Quality Control	3.9.2	FIO														

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		07240	SD-10 Operation and Maintenance																
			Data																
			Exterior Insulation and Finish	1.3	FIO														
			System																
		07416	SD-02 Shop Drawings																
			Structural Standing Seam Metal	1.5.2	FIO														
			Roof System																
			SD-03 Product Data																
			Design Analysis		FIO														
			Qualifications		FIO														
			SD-04 Samples																
			Accessories	2.3	FIO														
			Roof Panels	2.1	FIO														
			Factory Color Finish	2.5	FIO														
			Fasteners	2.4	FIO														
			Gaskets and Insulating	2.7	FIO														
			Compounds																
			Sealant	2.6	FIO														
			Concealed Anchor Clips	2.2	FIO														
			SD-06 Test Reports																
			Test Report for Uplift Resistance	1.5.1	FIO														
			of the SSSMR																
			SD-07 Certificates																
			Structural Standing Seam Metal	1.5.2	FIO														
			Roof System																
		07510	SD-03 Product Data																

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		07510	Inspection	3.16	FIO													
			SD-07 Certificates															
			Bitumen	2.2	FIO													
			Felt	2.5	FIO													
			Cants	2.4	FIO													
		07600	SD-02 Shop Drawings															
			Materials	2.1	FIO													
		07840	SD-02 Shop Drawings															
			Firestopping Materials	2.1	FIO													
			SD-07 Certificates															
			Firestopping Materials	2.1	FIO													
			Installer Qualifications	1.5	FIO													
			Inspection	3.3	FIO													
		07900	SD-03 Product Data															
			Backing	2.1	FIO													
			Bond-Breaker	2.2	FIO													
			Sealant	2.4	FIO													
			SD-07 Certificates															
			Sealant	2.4	FIO													
		08210	SD-02 Shop Drawings															
			Fire Doors	3.1.2	FIO													
			Wood Doors and Frames	1.3.1	FIO													
			SD-07 Certificates															
			Fire Doors	3.1.2	FIO													
			Adhesives	2.1.3	FIO													
		08250	SD-02 Shop Drawings															

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		08250	FRP Doors and Frames	2.1	FIO														
			SD-03 Product Data																
			FRP Doors and Frames	2.1	FIO														
			SD-07 Certificates																
			FRP Doors and Frames	2.1	FIO														
		08560	SD-02 Shop Drawings																
			Vinyl Windows	2.1	FIO														
			Insect Screens	2.6	FIO														
			SD-03 Product Data																
			Vinyl Windows	2.1	FIO														
			Insect Screens	2.6	FIO														
			Installation	3.1	FIO														
			Cleaning	3.3	FIO														
			SD-04 Samples																
			Finish	2.5	FIO														
			SD-07 Certificates																
			Vinyl Windows	2.1	FIO														
			Insect Screens	2.6	FIO														
		08700	SD-03 Product Data																
			Hardware Schedule	1.3	FIO														
			Keying	2.5	G RE														
			Keying System	1.2.1	G RE														
			SD-07 Certificates																
			Hardware and Accessories	1.2.2	FIO														
		08810	SD-02 Shop Drawings																
			Installation	3.2	FIO														

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		08810	SD-03 Product Data																
			Glazing Accessories	2.3	FIO														
		09250	SD-02 Shop Drawings																
			Steel Framing	2.5.1	FIO														
			Steel Framing	3.1	FIO														
			SD-07 Certificates																
			Gypsum Wallboard	2.4.1	FIO														
			Gypsum Wallboard	3.7	FIO														
			Steel Framing	2.5.1	FIO														
			Steel Framing	3.1	FIO														
			Cementitious Backer Units	2.6	FIO														
		09310	SD-03 Product Data																
			Tile	2.1	FIO														
			Tile	2.1	FIO														
			Mortar and Grout	2.4	FIO														
			Mortar and Grout	2.4	FIO														
			SD-04 Samples																
			Tile	2.1	FIO														
			Marble Thresholds	2.5	FIO														
			SD-07 Certificates																
			Tile	2.1	FIO														
			Mortar and Grout	2.4	FIO														
		09510	SD-02 Shop Drawings																
			Approved Detail Drawings	1.3	FIO														
			SD-03 Product Data																
			Acoustical Ceiling Systems	1.2.1	FIO														

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		09510	SD-04 Samples															
			Acoustical Units	2.1	FIO													
			SD-06 Test Reports															
			Ceiling Attenuation Class and	2.5	FIO													
			Test															
			SD-07 Certificates															
			Acoustical Units	2.1	FIO													
		09650	SD-03 Product Data															
			Resilient Flooring and	1.2.1	FIO													
			Accessories															
			SD-04 Samples															
			Flooring	3.2	FIO													
			SD-06 Test Reports															
			Moisture Test	3.3	FIO													
		09900	SD-03 Product Data															
			Paint	2.1	FIO													
			Mixing and Thinning	3.3	FIO													
			Application	3.4	FIO													
			SD-04 Samples															
			Moisture-Curing Polyurethane	1.5	FIO													
			Paint	2.1	FIO													
			SD-06 Test Reports															
			Paint	2.1	FIO													
			SD-07 Certificates															
			Lead	2.1.3	FIO													
			Mildewcide and Insecticide	2.1.2	FIO													

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		09900	Volatile Organic Compound	2.1.5	FIO														
			(VOC) Content																
		10161	SD-02 Shop Drawings																
			Shower Partition System	1.2	FIO														
			Shower Partition System	2.2	FIO														
			SD-03 Product Data																
			Shower Partition System	1.2	FIO														
			Shower Partition System	2.2	FIO														
			SD-04 Samples																
			Shower Partition System	1.2	FIO														
			Shower Partition System	2.2	FIO														
		10201	SD-02 Shop Drawings																
			Metal Wall Louvers	2.1	FIO														
			Metal Wall Louvers	3.1	FIO														
			SD-03 Product Data																
			Metal Wall Louvers	2.1	FIO														
			Metal Wall Louvers	3.1	FIO														
		10440	SD-03 Product Data																
			Installation	3.1	FIO														
			SD-04 Samples																
			Interior Signage	1.3	FIO														
		10505	SD-02 Shop Drawings																
			Solid plastic lockers	2.1	FIO														
			SD-03 Product Data																
			Solid plastic lockers	2.1	FIO														
		10800	SD-03 Product Data																

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		10800	Finishes	2.1.2	FIO													
			Accessory Items	2.2	FIO													
			SD-04 Samples															
			Finishes	2.1.2	FIO													
			Accessory Items	2.2	FIO													
		11551	SD-02 Shop Drawings															
			Pallet Storage Racks	1.3.1	FIO													
			Seismic Protection	1.3.1.2	FIO													
			Aisle Signs and Labels	2.3	FIO													
			SD-03 Product Data															
			Pallet Storage Racks	1.3.1	FIO													
			SD-07 Certificates															
			Pallet Storage Racks Certification	1.2.1	FIO													
		12490	SD-02 Shop Drawings															
			Approved Detail Drawings	3.1	FIO													
			SD-03 Product Data															
			Window Treatments	3.1	FIO													
			Hardware	1.3	FIO													
			SD-04 Samples															
			Window Treatments	3.1	FIO													
		13038	SD-02 Shop Drawings															
			Cold storage rooms	2.1	FIO													
			SD-03 Product Data															
			Cold storage rooms	2.1	FIO													
			SD-08 Manufacturer’s Instructions															
			Cold storage rooms	2.1	FIO													

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		13038	SD-10 Operation and Maintenance															
			Data															
			Cold storage rooms	2.1	G	ED												
		13040	SD-02 Shop Drawings															
			Hydronic Floor Warming System	1.2	FIO													
			SD-03 Product Data															
			Spare Parts	1.4.1	FIO													
			SD-06 Test Reports															
			Test Reports	1.4.2	FIO													
			SD-08 Manufacturer’s Instructions															
			Hydronic Floor Warming System	1.2	FIO													
			SD-10 Operation and Maintenance															
			Data															
			Hydronic Floor Warming System	1.2	G	ED												
		13080	SD-02 Shop Drawings															
			Bracing	3.1	FIO													
			Resilient Vibration Isolation	3.4	FIO													
			Devices															
			Equipment Requirements	1.2.1	FIO													
			SD-03 Product Data															
			Bracing	3.1	FIO													
			Equipment Requirements	1.2.1	FIO													
		13280	SD-03 Product Data															
			Respiratory Protection Program	1.12	G	RE												
			Cleanup and Disposal	3.11	G	RE												
			Detailed Drawings	3.6.5.2	G	RE												

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		13280	Detailed Drawings	3.9.2	G	RE												
			Materials and Equipment		G	RE												
			Qualifications	1.5	G	RE												
			Training Program	1.11	G	RE												
			Medical Requirements	1.10	G	RE												
			Encapsulants	2.1	G	RE												
			SD-06 Test Reports															
			Exposure Assessment and Air	3.9	G	RE												
			Monitoring															
			Local Exhaust Ventilation	1.20	G	RE												
			Licenses, Permits and	1.14	G	RE												
			Notifications															
			SD-07 Certificates															
			Vacuum, Filtration and Ventilation		G	RE												
			Equipment															
		13281	SD-03 Product Data															
			Materials and Equipment	1.18	G	RE												
			Expendable Supplies	1.19	G	RE												
			Qualifications	1.5	G	RE												
			SD-06 Test Reports															
			Licences, Permits, and	1.11	G	RE												
			Notifications															
			Accident Prevention Plan (APP)	1.7	G	RE												
			Sampling and Analysis	1.13	G	RE												
			Clearance Report	3.7	G	RE												
		13286	SD-07 Certificates															

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		13286	Qualifications of CIH	1.8.1	G														
			Training Certification	1.8.1	G														
			PCB and Mercury-Containing	1.8.2	G														
			Lamp Removal Work Plan																
			PCB and Mercury-Containing	1.8.3	G														
			Lamp Disposal Plan																
			SD-11 Closeout Submittals																
			Transporter certification	3.5.2	G														
			Certification of Decontamination	3.2.4	G														
			Certificate of Disposal and/or	3.5.2.1	FIO														
			recycling																
		13851	SD-02 Shop Drawings																
			Fire Alarm Reporting System	1.4.1	G	RE													
			SD-03 Product Data																
			Storage Batteries	2.2	G	RE													
			Special Tools and Spare Parts	2.7.3	FIO														
			Technical Data and Computer	1.5	G	RE													
			Software																
			Training	3.5	FIO														
			Testing	3.4	FIO														
			Voltage Drop	1.2.1	G	RE													
			SD-06 Test Reports																
			Testing	3.4	FIO														
			SD-07 Certificates																
			Equipment	1.3.1	FIO														
			Equipment	1.3.6	FIO														

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		13851	Qualifications	1.3.7	G	RE												
			SD-10 Operation and Maintenance															
			Data															
			Technical Data and Computer	1.5	G	RE												
			Software															
		13930	SD-02 Shop Drawings															
			Sprinkler System Shop Drawings		G	RE												
			As-Built Shop Drawings		FIO													
			SD-03 Product Data															
			Fire Protection Related Submittals	3.1	FIO													
			Fire Protection Related Submittals	3.1	FIO													
			Load Calculations for Sizing Sway	1.6.1	G	RE												
			Bracing															
			Components and Equipment Data		G	RE												
			Hydraulic Calculations	1.7	G	RE												
			Spare Parts	1.6.3	FIO													
			Preliminary Tests Procedures	1.6.3	G	RE												
			Final Acceptance Test Procedures	1.6.3	G	RE												
			On-site Training Schedule	1.6.3	G	RE												
			Preliminary Tests	3.10	G	RE												
			Final Acceptance Test	3.11	G	RE												
			Fire Protection Specialist	1.8	G	RE												
			Qualifications															
			Sprinkler System Installer	1.9	G	RE												
			Qualifications															
			SD-06 Test Reports															

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		13930	Preliminary Tests Report	1.6.4	G	RE												
			Final Acceptance Test Report	1.6.4	G	RE												
			SD-07 Certificates															
			Fire Protection Specialist	3.3	G	RE												
			Inspection															
			SD-10 Operation and Maintenance															
			Data															
			Wet Pipe Sprinkler System	1.2	FIO													
		15070	SD-02 Shop Drawings															
			Contractor Designed Bracing	1.2.4	G	ED												
			SD-03 Product Data															
			Coupling and Bracing	3.1	FIO													
			Equipment Requirements	1.3	FIO													
			Contractor Designed Bracing	1.2.4	G	RE												
			SD-07 Certificates															
			Flexible Ball Joints	2.2	FIO													
		15080	SD-04 Samples															
			Thermal Insulation Materials	1.4.1	FIO													
		15400	SD-02 Shop Drawings															
			Plumbing System	3.7.1	FIO													
			Electrical Schematics	1.5.1	FIO													
			SD-03 Product Data															
			Plumbing Fixture Schedule	3.8	FIO													
			Vibration-Absorbing Features		FIO													
			Plumbing System	3.7.1	FIO													
			SD-06 Test Reports															

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		15400	Tests, Flushing and Disinfection	3.7	FIO														
			SD-07 Certificates																
			Materials and Equipment	1.5.2	FIO														
			Bolts	1.5.2	FIO														
			SD-10 Operation and Maintenance																
			Data																
			Plumbing System	3.7.1	FIO														
		15652	SD-02 Shop Drawings																
			Refrigeration System	2.8	G ED														
			Drawings	1.4.2	FIO														
			Drawings	3.1.9	FIO														
			SD-03 Product Data																
			Refrigeration System	2.8	FIO														
			Framed Instructions	3.1.24	FIO														
			Qualifications		FIO														
			Verification of Dimensions	1.4.1	FIO														
			Tests	1.2.1	G ED														
			Tests	3.2	FIO														
			Demonstrations	3.4	G ED														
			Spare Parts Data	1.2.1	FIO														
			SD-07 Certificates																
			Refrigeration System	2.8	FIO														
			Service Organizations	1.2.2	FIO														
		15653	SD-02 Shop Drawings																
			Drawings	1.4.2	G ED														
			SD-03 Product Data																

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		15653	Air-Conditioning System	1.2.3	FIO														
			Spare Parts Data	1.2.2	FIO														
			Framed Instructions	1.2.2	FIO														
			Framed Instructions	3.1.3	FIO														
			SD-06 Test Reports																
			Tests	1.2.2	FIO														
			Tests	3.2	FIO														
			System Performance Tests		FIO														
			Inspections		FIO														
			SD-07 Certificates																
			Air-Conditioning System	1.2.3	FIO														
			Service Organizations	1.2.3	FIO														
			SD-10 Operation and Maintenance																
			Data																
			Operation	2.3	FIO														
			Operation	3.4	FIO														
			Maintenance Manuals	3.4	FIO														
		15895	SD-02 Shop Drawings																
			Drawings	1.4.1	FIO														
			Installation	3.1	FIO														
			SD-03 Product Data																
			Components and Equipment	2.1	FIO														
			Test Procedures		FIO														
			System Diagrams		G ED														
			Similar Services		FIO														
			Testing, Adjusting and Balancing	3.6	FIO														

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		15895	Field Training	3.8	FIO													
			SD-06 Test Reports															
			Performance Tests	3.7	FIO													
			SD-07 Certificates															
			Bolts		FIO													
			SD-10 Operation and Maintenance															
			Data															
			Operating and Maintenance	3.8	FIO													
			Instructions															
		15951	SD-02 Shop Drawings															
			HVAC and Refrigeraton Control	3.1.1	FIO													
			System															
			SD-03 Product Data															
			Service Organizations		FIO													
			Equipment Compliance Booklet	1.6	FIO													
			Commissioning Procedures	3.5	FIO													
			Performance Verification Test	1.6	FIO													
			Procedures															
			Training	3.7	FIO													
			SD-06 Test Reports															
			Commissioning Report	3.7.2	FIO													
			Performance Verification Test	3.6.3	FIO													
			SD-10 Operation and Maintenance															
			Data															
			Operation Manual	1.5	FIO													
			Maintenance and Repair Manual	1.6	G ED													

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		15990	SD-02 Shop Drawings																
			TAB Schematic Drawings and	3.3	FIO														
			Report Forms																
			SD-03 Product Data																
			TAB Related HVAC Submittals	3.2	FIO														
			TAB Procedures	3.5.1	G	ED													
			Calibration	1.4	FIO														
			Systems Readiness Check	3.5.2	FIO														
			TAB Execution	3.5.1	G	ED													
			TAB Verification	3.5.4	G	ED													
			SD-06 Test Reports																
			Design Review Report	3.1	G	ED													
			Systems Readiness Check	3.5.2	G	ED													
			TAB Report	3.5.3	G	ED													
			TAB Verification Report	3.5.4	G	ED													
			SD-07 Certificates																
			Ductwork Leak Testing	3.4	FIO														
			TAB Firm	1.5.1	G	ED													
			TAB Specialist	1.5.2	G	ED													
		15995	SD-03 Product Data																
			Commissioning Team	3.1	FIO														
			Test Procedures		FIO														
			Test Schedule		G	ED													
			SD-06 Test Reports																
			Test Reports		G	ED													
		16360	SD-02 Shop Drawings																

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		16360	Unit Substation Drawings	1.5.1.1	G	RE												
			SD-03 Product Data															
			Secondary Unit Substation	2.2	G	RE												
			SD-06 Test Reports															
			Ground resistance test reports	1.5.2	G	RE												
			acceptance checks and tests	3.5.1	G	RE												
			SD-07 Certificates															
			Transformer losses	1.5.3	G	RE												
			SD-09 Manufacturer’s Field															
			Reports															
			Switchgear design and production	2.4.2	G	RE												
			tests															
			design tests (dry-type)	2.4.4	G	RE												
			routine and other tests (dry-type)	2.4.5	G	RE												
			SD-10 Operation and Maintenance															
			Data															
			Unit substations	1.6.1	G	RE												
			Transformer (dry-type)	2.2.3	G	RE												
			SD-11 Closeout Submittals															
			Equipment test schedule	2.4.1	G	RE												
		16375	SD-02 Shop Drawings															
			Electrical Distribution System	3.9.3	G	RE												
			As-Built Drawings		G	RE												
			SD-03 Product Data															
			Fault Current Analysis		G	RE												
			Protective Device		G	RE												

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		16375	Nameplates	2.2	FIO													
			Material and Equipment	2.1	FIO													
			General Installation Requirements	3.1	FIO													
			SD-06 Test Reports															
			Factory Tests	2.13	FIO													
			Field Testing	3.9	FIO													
			Cable Installation	3.2.1.4	FIO													
			SD-07 Certificates															
			Material and Equipment	2.1	FIO													
			Cable Joints	3.3	FIO													
			Cable Installer Qualifications	1.3.1	FIO													
			SD-10 Operation and Maintenance															
			Data															
			Electrical Distribution System	3.9.3	FIO													
		16415	SD-02 Shop Drawings															
			Emergency Power Supply (EPS)	2.20	G	RE												
			Interior Electrical Equipment	1.3.1	G	RE												
			SD-03 Product Data															
			Manufacturer's Catalog	1.3.2	FIO													
			Material, Equipment, and Fixture	1.3.3	FIO													
			Lists															
			Installation Procedures	1.3.4	FIO													
			As-Built Drawings	1.2.6	FIO													
			As-Built Drawings	1.3.5	FIO													
			Onsite Tests	1.3.6	G	RE												
			SD-06 Test Reports															

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		16415	Factory Test Reports	1.3.7	G	RE													
			Field Test Plan	1.3.8	G	RE													
			Field Test Reports	1.3.9	G	RE													
			Field Test Reports	3.18	G	RE													
			SD-07 Certificates																
			Materials and Equipment	1.4	FIO														
		16528	SD-02 Shop Drawings																
			Lighting System	1.3.1	G	RE													
			Detail Drawings	1.2.1	G	RE													
			As-Built Drawings	1.2.1	FIO														
			SD-03 Product Data																
			Equipment and Materials	1.3.6	FIO														
			SD-06 Test Reports																
			Operating Test	3.7.1	G	RE													
			SD-10 Operation and Maintenance																
			Data																
			Lighting System	1.3.1	FIO														
		16710	SD-02 Shop Drawings																
			Premises Distribution System	1.7	G	RE													
			Record Drawings	1.5.1	G	RE													
			SD-03 Product Data																
			Record Keeping and	1.8	G	RE													
			Documentation																
			Manufacturer's Recommendations	3.1.2	G	RE													
			Qualifications	1.4	G	RE													
			Test Plan	1.5.2	G	RE													

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		16710	Spare Parts	1.5.3	FIO													
			SD-06 Test Reports															
			Test Reports	1.5.4	FIO													
			SD-07 Certificates															
			Premises Distribution System	1.7	FIO													
			Materials and Equipment	2.1	FIO													
			Installers		G	RE												

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DIVISION 03 - CONCRETE

SECTION 03300

CAST-IN-PLACE STRUCTURAL CONCRETE

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SECTION 03300

CAST-IN-PLACE STRUCTURAL CONCRETE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 117/117R	(1990; Errata) Standard Tolerances for Concrete Construction and Materials
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214.3R	(1988) Simplified Version of the Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 305R	(1991) Hot Weather Concreting
ACI 318/318R	(1999) Building Code Requirements for Structural Concrete and Commentary

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 182	(1991; R 1996) Burlap Cloth Made From Jute or Kenaf

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 31/C 31M	(1998) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(19999a) Concrete Aggregates
ASTM C 39	(1996) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42	(1999) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 78	(1994) Flexural Strength of Concrete (Using Simple Beam With Third-Point Loading)
ASTM C 94	(1999) Ready-Mixed Concrete

ASTM C 131	(1996) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(1996a) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 143	(1998) Slump of Hydraulic Cement Concrete
ASTM C 150	(1998a) Portland Cement
ASTM C 171	(1997a)Sheet Materials for Curing Concrete
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 173	(1994ael) Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192/C 192M	(1998) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(1997el) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(1998) Air-Entraining Admixtures for Concrete
ASTM C 309	(1998a) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494	(1999) Chemical Admixtures for Concrete
ASTM C 552	(1991) Cellular Glass Thermal Insulation
ASTM C 578	(1995) Rigid, Cellular Polystyrene Thermal Insulation
ASTM C 591	(1994) Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 1017	(1998) Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C 1059	(1999) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(1999) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1077	(1998) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

ASTM C 1107	(1999) Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM D 638	(2000) Test Method for Tensile Properties of Plastics
ASTM D 75	(1987; R 1997) Sampling Aggregates
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM E 96	(1995) Water Vapor Transmission of Materials
ASTM E 154	(1999) Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover
ASTM E 1155M	(1996) Determine Floor Flatness and Levelness Using the F-Number System (Metric)
ASTM E 1745	(1997) Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

CORPS OF ENGINEERS (COE)

COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 540	(1971; R 1981) Standard Specification for Nonbituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type
COE CRD-C 572	(1974) Corps of Engineers Specifications for Polyvinylchloride Waterstop

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(1997) NIST Handbook 44: Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices

NATIONAL READY-MIXED CONCRETE ASSOCIATION (NRMCA)

NRMCA CPMB 100	(1996) Concrete Plant Standards

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Mixture Proportions; G, RE

The results of trial mixture design studies along with a statement giving the maximum nominal coarse aggregate size and the proportions of ingredients that will be used in the manufacture of each strength or class of concrete, at least 14 days prior to commencing concrete placing operations. Aggregate weights shall be based on the saturated surface dry condition. The statement shall be accompanied by test results from an approved independent commercial testing laboratory, showing that mixture design studies have been made with materials proposed for the project and that the proportions selected will produce concrete of the qualities indicated. No substitutions shall be made in the materials used in the mixture design studies without additional tests to show that the quality of the concrete is satisfactory.

SD-06 Test Reports

Testing and Inspection for Contractor Quality Control; G, RE

Certified copies of laboratory test reports, including mill tests and all other test data, for portland cement, aggregate, admixtures, and curing compound proposed for use on this project.

SD-07 Certificates

Qualifications.

Written documentation for Contractor Quality Control personnel.

1.3 QUALIFICATIONS

Contractor Quality Control personnel assigned to concrete construction shall be American Concrete Institute (ACI) Certified Workmen in one of the following grades or shall have written evidence of having completed similar qualification programs:

Concrete Field Testing Technician, Grade I
Concrete Laboratory Testing Technician, Grade I or II
Concrete Construction Inspector, Level II

Concrete Transportation Construction Inspector or
Reinforced Concrete Special Inspector, Jointly certified by American Concrete Institute (ACI), Building Official and Code Administrators International (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International (SBCCI).

The foreman or lead journeyman of the flatwork finishing crew shall have

similar qualification for ACI Concrete Flatwork Technician/Finisher or equal, with written documentation.

1.4 FIELD TEST PANELS

Field test panels shall be constructed prior to beginning of work using the materials and procedures proposed for use on the job, to demonstrate the results to be attained. The quality and appearance of each panel shall be subject to the approval of the Contracting Officer, and, if not judged satisfactory, additional panels shall be constructed until approval is attained. Formed or finished surfaces in the completed structure shall match the quality and appearance of the approved field example.

1.4.1 Sample Wall Panels

One sample panel at least 1220 mm by 1525 mm and 150 mm thick shall be constructed to demonstrate Class A formed finish. Panels shall be located at the pre-casting yard. Each panel shall include a full length and full width joint line and shall have at least two voids each at least 300 mm by 300 mm by 75 mm deep either impressed in the concrete as placed or chipped in the hardened concrete. After the concrete is 7 days old, the voids shall be patched to demonstrate the effectiveness and the appearance of the Contractor's repair procedures.

1.4.2 Slab Panels

A slab panel at least 1220 mm by 1525 mm and 100 mm thick shall be constructed to demonstrate slab finish. Panels shall be located at the pre-casting yard. Each panel shall have a full length joint line.

1.5 SPECIAL REQUIREMENTS

A pre-installation meeting with the Contracting Officer will be required at least 10 days prior to start of construction. The Contractor shall be responsible for calling the meeting; the Project Superintendent and active installation personnel shall be present.

1.6 GENERAL REQUIREMENTS

1.6.1 Tolerances

Except as otherwise specified herein, tolerances for concrete batching, mixture properties, and construction as well as definition of terms and application practices shall be in accordance with ACI 117/117R. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing; when forms or shoring are used, the measurements shall be made prior to removal.

1.6.1.1 Floors

For the purpose of this Section the following terminology correlation between ACI 117/117R and this Section shall apply:

Floor Profile Quality Classification From ACI 117/117R	This Section
Conventional Bullfloated	Same
Conventional Straightedged	Same

Floor Profile Quality Classification From ACI 117/117R	This Section
Flat	Float Finish or Trowel Finish
Very Flat	Same. Use only with F-system

Levelness tolerance shall not apply where design requires floors to be sloped to drains or sloped for other reasons.

1.6.1.2 Floors by the F-Number System

The flatness and levelness of floors shall be carefully controlled and the tolerances shall be measured by the F-Number system of Paragraph 4.5.6 and 4.5.6.1 of ACI 117/117R. The Contractor shall furnish an approved floor profilograph or other equipment capable of measuring the floor flatness (FF) number and the floor levelness (FL) number in accordance with ASTM E 1155M . The Contractor shall perform the tolerance measurements within 72 hours after floor slab construction while being observed by the Contracting Officer. The tolerances of surfaces beyond the limits of ASTM E 1155M (the areas within 600 mm of embedments and construction joints) shall be acceptable to the Contracting Officer. Tolerances of the following areas shall meet the requirements for the listed surfaces as specified in paragraphs 4.5.6 and 4.5.6.1 of ACI 117/117R.

Trowel Finish-	Areas - all other areas inside the building
Very Flat-	Areas - Refrigerated and Freezer Rooms

1.6.2 Strength Requirements and w/c Ratio

1.6.2.1 Strength Requirements

Specified compressive strength (f'c) shall be as follows:

COMPRESSIVE STRENGTH	STRUCTURE OR PORTION OF STRUCTURE
27.5 MPa at 28 days	Foundations, Composite topping over precast double tees, concrete topping over refrigeration and freezer floors, pavements
20 MPa at 28 days	Curbs, sidewalks and all other concrete.

Concrete slabs on-grade shall have a 28-day flexural strength of 4.5 MPa. Concrete made with high-early strength cement shall have a 7-day strength equal to the specified 28-day strength for concrete made with Type II portland cement. Compressive strength shall be determined in accordance with ASTM C 39. Flexural strength shall be determined with ASTM C 78.

a. Evaluation of Concrete Compressive Strength. Compressive strength specimens (152 by 305 mm cylinders) shall be fabricated by the Contractor and laboratory cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result

falls below the specified strength f'c by more than 3.5 MPa. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

b. Investigation of Low-Strength Compressive Test Results. When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 3.5 MPa or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Contracting Officer to least impair the strength of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement. Non-destructive tests (tests other than test cylinders or cores) shall not be used as a basis for acceptance or rejection. The Contractor shall perform the coring and repair the holes. Cores will be tested by the Government.

c. Load Tests. If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Contracting Officer in accordance with the requirements of ACI 318/318R. Concrete work evaluated by structural analysis or by results of a load test as being understrength shall be corrected in a manner satisfactory to the Contracting Officer. All investigations, testing, load tests, and correction of deficiencies shall be performed by and at the expense of the Contractor and must be approved by the Contracting Officer, except that if all concrete is found to be in compliance with the drawings and specifications, the cost of investigations, testing, and load tests will be at the expense of the Government.

d. Evaluation of Concrete Flexural Strength. Flexural strength specimens (beams) shall be fabricated by the Contractor and laboratory cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 78. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified flexural strength and no individual test result falls below the specified flexural strength by more than 350 kPa.A "test" is defined as the average of two companion beams. Additional analysis or testing, including taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the slab is considered potentially deficient.

1.6.2.2 Water-Cement Ratio

Maximum water-cement ratio (w/c) for normal weight concrete shall be as

follows:

WATER-CEMENT RATIO, BY WEIGHT	STRUCTURE OR PORTION OF STRUCTURE
0.40	All concrete with compressive strength of 27.5 MPa at 28 days.
0.45	All other concrete

These w/c's may cause higher strengths than that required above for compressive or flexural strength. The maximum w/c required will be the equivalent w/c as determined by conversion from the weight ratio of water to cement by the weight equivalency method as described in ACI 211.1.

1.6.3 Air Entrainment

All normal weight concrete shall be air entrained to contain between 5 and 7 percent total air, except that when the nominal maximum size coarse aggregate is 19 mm or smaller it shall be between 4.5 and 7.5 percent. Specified air content shall be attained at point of placement into the forms. Air content for normal weight concrete shall be determined in accordance with ASTM C 231.

1.6.4 Slump

Slump of the concrete, as delivered to the point of placement into the forms, shall be within the following limits. Slump shall be determined in accordance with ASTM C 143.

Structural Element	Slump Minimum	Slump Maximum
Walls, columns and beams	50 mm	100 mm
Foundation walls, substructure walls, footings, slabs	25 mm	75 mm
Any structural concrete approved for placement by pumping:		
At pump	50 mm	150 mm
At discharge of line	25 mm	100 mm

When use of a plasticizing admixture conforming to ASTM C 1017 or when a Type F or G high range water reducing admixture conforming to ASTM C 494 is permitted to increase the slump of concrete, concrete shall have a slump of 50 to 100 mm before the admixture is added and a maximum slump of 200 mm at the point of delivery after the admixture is added.

1.6.5 Concrete Temperature

The temperature of the concrete as delivered shall not exceed 32 degrees C. When the ambient temperature during placing is 5 degrees C or less, or is expected to be at any time within 6 hours after placing, the temperature of the concrete as delivered shall be between 12 and 25 degrees C.

1.6.6 Size of Coarse Aggregate

The largest feasible nominal maximum size aggregate (NMSA) specified in paragraph AGGREGATES shall be used in each placement. However, nominal maximum size of aggregate shall not exceed any of the following: three-fourths of the minimum cover for reinforcing bars, three-fourths of the minimum clear spacing between reinforcing bars, one-fifth of the narrowest dimension between sides of forms, or one-third of the thickness of slabs or toppings.

1.6.7 Special Properties and Products

Concrete may contain admixtures other than air entraining agents, such as water reducers, superplasticizers, or set retarding agents to provide special properties to the concrete, if specified or approved. Any of these materials to be used on the project shall be used in the mix design studies.

1.7 MIXTURE PROPORTIONS

Concrete shall be composed of portland cement, aggregates, water and admixtures as specified.

1.7.1 Proportioning Studies for Normal Weight Concrete

Trial design batches, mixture proportioning studies, and testing requirements for various classes and types of concrete specified shall be the responsibility of the Contractor. Except as specified for flexural strength concrete, mixture proportions shall be based on compressive strength as determined by test specimens fabricated in accordance with ASTM C 192/C 192M and tested in accordance with ASTM C 39. Samples of all materials used in mixture proportioning studies shall be representative of those proposed for use in the project and shall be accompanied by the manufacturer's or producer's test reports indicating compliance with these specifications. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios for each type of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project. The maximum water-cement ratios required in subparagraph Water-Cement Ratio will be the equivalent water-cement ratio as determined by conversion from the weight ratio of water to cement by the weight equivalency method as described in ACI 211.1. Laboratory trial mixtures shall be designed for maximum permitted slump and air content. Separate sets of trial mixture studies shall be made for each combination of cementitious materials and each combination of admixtures proposed for use. No combination of either shall be used until proven by such studies, except that, if approved in writing and otherwise permitted by these specifications, an accelerator or a retarder may be used without separate trial mixture study. Separate trial mixture studies shall also be made for concrete for any conveying or placing method proposed which requires special properties and for concrete to be placed in unusually difficult placing locations. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance withASTM C 192/C 192M. They shall be tested at 7 and 28 days in accordance with ASTM C 39. From these test results, a curve shall be plotted showing the relationship between water-cement ratio and strength for each set of trial mix studies. In addition, a curve shall be plotted showing the relationship between 7 day and 28 day strengths. Each mixture shall be designed to promote easy and suitable concrete placement, consolidation and finishing, and to prevent segregation and excessive bleeding.

1.7.2 Average Compressive Strength Required for Mixtures

The mixture proportions selected during mixture design studies shall produce a required average compressive strength (f'cr) exceeding the specified compressive strength (f'c) by the amount indicated below. This required average compressive strength, f'cr, will not be a required acceptance criteria during concrete production. However, whenever the daily average compressive strength at 28 days drops below f'cr during concrete production, or daily average 7-day strength drops below a strength correlated with the 28-day f'cr, the mixture shall be adjusted, as approved, to bring the daily average back up to f'cr. During production, the required f'cr shall be adjusted, as appropriate, based on the standard deviation being attained on the job.

1.7.2.1 Computations from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214.3R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected; shall represent concrete produced to meet a specified strength or strengths (f'c) within 7 MPa of that specified for proposed work; and shall consist of at least 30 consecutive tests. A strength test shall be the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days. Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

f'cr = f'c + 1.34S where units are in MPa

f'cr = f'c + 2.33S - 3.45 where units are in MPa

Where S = standard deviation

Where a concrete production facility does not have test records meeting the requirements above but does have a record based on 15 to 29 consecutive tests, a standard deviation shall be established as the product of the calculated standard deviation and a modification factor from the following table:

NUMBER OF TESTS	MODIFICATION FACTOR FOR STANDARD DEVIATION
15	1.16
20	1.08
25	1.03
30 or more	1.00

1.7.2.2 Computations without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength f'cr shall be determined as follows:

a. If the specified compressive strength f'c is less than 20 MPa,

f'cr = f'c + 6.9 MPa

b. If the specified compressive strength f'c is 20 to 35 MPa,

f'cr = f'c + 8.3 MPa

1.7.3 Mix Design for Topping for Refrigeration and Freezer Floors

The concrete mix design for bonded topping for heavy duty floors shall contain the greatest practical proportion of coarse aggregate within the specified proportion limits. The mix shall be designed to produce concrete having a 28-day strength of at least 34.5 MPa. Concrete for the topping shall consist of the following proportions, by weight:

1.00 part portland cement
1.15 to 1.25 parts fine aggregate
1.80 to 2.00 parts coarse aggregate

Maximum w/c shall be 0.33. The topping concrete shall not be air-entrained. The concrete shall be mixed so as to produce a mixture of the driest consistency possible to work with a sawing motion of the strike-off and which can be floated and compacted as specified without producing water or excess cement at the surface. In no case shall slump exceed 25 mm as determined by ASTM C 143.

1.8 STORAGE OF MATERIALS

Cement and other cementitious materials shall be stored in weathertight buildings, bins, or silos which will exclude moisture and contaminants and keep each material completely separated. Aggregate stockpiles shall be arranged and used in a manner to avoid excessive segregation and to prevent contamination with other materials or with other sizes of aggregates. Aggregate shall not be stored directly on ground unless a sacrificial layer is left undisturbed. Reinforcing bars and accessories shall be stored above the ground on platforms, skids or other supports. Other materials shall be stored in such a manner as to avoid contamination and deterioration. Admixtures which have been in storage at the project site for longer than 6 months shall not be used unless retested and proven to meet the specified requirements. Materials shall be capable of being accurately identified after bundles or containers are opened.

1.9 GOVERNMENT ASSURANCE INSPECTION AND TESTING

Day-to day inspection and testing shall be the responsibility of the Contractor Quality Control (CQC) staff. However, representatives of the Contracting Officer can and will inspect construction as considered appropriate and will monitor operations of the Contractor's CQC staff. Government inspection or testing will not relieve the Contractor of any of his CQC responsibilities.

1.9.1 Materials

The Government will sample and test aggregates, cementitious materials, other materials, and concrete to determine compliance with the specifications as considered appropriate. The Contractor shall provide facilities and labor as may be necessary for procurement of representative

test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Other materials will be sampled from storage at the jobsite or from other locations as considered appropriate. Samples may be placed in storage for later testing when appropriate.

1.9.2 Fresh Concrete

Fresh concrete will be sampled as delivered in accordance with ASTM C 172 and tested in accordance with these specifications, as considered necessary.

1.9.3 Hardened Concrete

Tests on hardened concrete will be performed by the Government when such tests are considered necessary.

1.9.4 Inspection

Concrete operations may be tested and inspected by the Government as the project progresses. Failure to detect defective work or material will not prevent rejection later when a defect is discovered nor will it obligate the Government for final acceptance.

PART 2 PRODUCTS

The Contractor shall provide and transport an adequate supply of cementitious materials, aggregates and approved chemical admixtures to the job site for providing site-mixed cast-in-place structural concrete as required by the Contract Documents.

2.1 CEMENTITIOUS MATERIALS

Cementitious Materials shall be portland cement, and shall conform to appropriate specifications listed below. Use of cementitious materials in concrete which will have surfaces exposed in the completed structure shall be restricted so there is no change in color, source, or type of cementitious material.

2.1.1 Portland Cement

ASTM C 150, Type II or III with a maximum 8 percent of tricalcium aluminate.

2.1.2 High-Early-Strength Portland Cement

ASTM C 150, Type III with tricalcium aluminate limited to 8 percent.

2.2 AGGREGATES

Aggregates shall conform to the following.

2.2.1 Fine Aggregate

Fine aggregate shall conform to the quality and gradation requirements of ASTM C 33.

2.2.2 Coarse Aggregate

Coarse aggregate shall conform to ASTM C 33, Class 5S, size designation 67.

2.2.3 Materials for Topping for Refrigeration and Freezer Floors

In addition to the requirements specified above, coarse aggregate used for this purpose shall be a well graded, hard, sound diabase, trap rock, emery, granite or other natural or manufactured aggregate having equivalent hardness and wearing qualities and shall have a percentage of loss not to exceed 30 after 500 revolutions when tested in accordance with ASTM C 131. Gradation of the aggregates when tested in accordance with ASTM C 136 shall be as follows:

Coarse Aggregate

Sieve Size	Cumulative Percent By Weight Passing
19 mm	100
12.5 mm	50-100
9.5 mm	25-50
4.75 mm	0-15
2.36 mm	0-8

Fine Aggregate

Sieve Size	Cumulative Percent By Weight Passing
9.5 mm	100
4.75 mm	95-100
2.36 mm	65-80
1.18 mm	45-65
0.600 mm	25-45
0.300 mm	5-15
0.150 mm	0-5

2.3 CHEMICAL ADMIXTURES

Chemical admixtures, when required or permitted, shall conform to the appropriate specification listed. Admixtures shall be furnished in liquid form and of suitable concentration for easy, accurate control of dispensing.

2.3.1 Air-Entraining Admixture

ASTM C 260 and shall consistently entrain the air content in the specified ranges under field conditions.

2.3.2 Accelerating Admixture

ASTM C 494, Type C or E, except that calcium chloride or admixtures containing calcium chloride shall not be used.

2.3.3 Water-Reducing or Retarding Admixture

ASTM C 494, Type A, B, or D, except that the 6-month and 1-year compressive and flexural strength tests are waived.

2.3.4 High-Range Water Reducer

ASTM C 494, Type F or G, except that the 6-month and 1-year strength requirements are waived. The admixture shall be used only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.3.5 Other Chemical Admixtures

Chemical admixtures for use in producing flowing concrete shall comply with ASTM C 1017, Type I or II. These admixtures shall be used only when approved in writing, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan and upon performance of separate mixture design studies.

2.4 CURING MATERIALS

2.4.1 Impervious-Sheet

Impervious-sheet materials shall conform to ASTM C 171, type optional, except, that polyethylene sheet shall not be used.

2.4.2 Membrane-Forming Compound

Membrane-Forming curing compound shall conform to ASTM C 309, Type 1-D or 2, except that only a styrene acrylate or chlorinated rubber compound meeting Class B requirements shall be used for surfaces that are to be painted or are to receive bituminous roofing, or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, waterproofing, or flooring specified. Nonpigmented compound shall contain a fugitive dye, and shall have the reflective requirements in ASTM C 309 waived.

2.4.3 Burlap and Cotton Mat

Burlap and cotton mat used for curing shall conform to AASHTO M 182.

2.5 WATER

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that non-potable water may be used if it meets the requirements of COE CRD-C 400.

2.6 NONSHRINK GROUT

Nonshrink grout shall conform to ASTM C 1107, Grade A B C, and shall be a commercial formulation suitable for the proposed application.

2.7 NONSLIP SURFACING MATERIAL

Nonslip surfacing material shall consist of 55 percent, minimum, aluminum oxide or silicon-dioxide abrasive ceramically bonded together to form a homogeneous material sufficiently porous to provide a good bond with portland cement paste; or factory-graded emery aggregate consisting of not less than 45 percent aluminum oxide and 25 percent ferric oxide. The aggregate shall be well graded from particles retained on the 0.6 mm sieve to particles passing the 2.36 mm sieve.

2.8 LATEX BONDING AGENT

Latex agents for bonding fresh to hardened concrete shall conform to ASTM C 1059.

2.9 EPOXY RESIN

Epoxy resins for use in repairs shall conform to ASTM C 881, Type V, Grade 2. Class as appropriate to the existing ambient and surface temperatures.

2.10 EMBEDDED ITEMS

Embedded items shall be of the size and type indicated or as needed for the application. Dovetail slots shall be galvanized steel. Hangers for suspended ceilings shall be as specified in Section 09510 ACOUSTICAL CEILINGS. Inserts for shelf angles and bolt hangers shall be of malleable iron or cast or wrought steel.

2.11 FLOOR HARDENER

Floor hardener shall be a colorless aqueous solution containing zinc silicofluoride, magnesium silicofluoride, or sodium silicofluoride. These silicofluorides can be used individually or in combination. Proprietary hardeners may be used if approved in writing by the Contracting Officer.

2.12 PERIMETER INSULATION

Perimeter insulation shall be polystyrene conforming to ASTM C 578, Type II; polyurethane conforming to ASTM C 591, Type II; or cellular glass conforming to ASTM C 552, Type I or IV.

2.13 VAPOR BARRIER

Vapor barrier shall be of the following properties:

a. Minimum 15-mil thick polyolefin geomembrane manufactured with ISO certified virgin resins.

b. Water Vapor Retarder ASTM E 1745 meets Class B Water Vapor Transmission Rate ASTM E 96 not exceeding 0.006 gr./ft2/hr.

c. Permeance Rating ASTM E 96 not exceeding 0.015 gr./ft2/hr.

d. Puncture Resistance ASTM E 154 minimum 1970 grams.

e. Tensile Strength ASTM D 638 minimum 45lbf/in.

1) Installation shall be in accordance manufacturer's instructions including taping procedures at the laps, tape material used, patching procedures, and installation at vertical walls.

2) No penetration of the vapor barrier, except as required at permanent utilities penetrations, shall be allowed.

3) The vapor barrier shall not be left exposed to ultraviolet rays for more than a day either in storage or prior to pouring of the concrete slab.

2.14 JOINT MATERIALS

2.14.1 Joint Fillers and Sealers

Expansion joint fillers shall be preformed materials conforming to ASTM D 1751. **Joint Sealants shall be as specified in Section SECTION 03151 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS IN CONCRETE FOR CIVIL WORKS.**

2.14.2 Contraction Joints in Slabs

Sawable type contraction joint inserts shall conform to COE CRD-C 540. Nonsawable joint inserts shall have sufficient stiffness to permit placement in plastic concrete without undue deviation from a straight line and shall conform to the physical requirements of COE CRD-C 540, with the exception of Section 3.4 "Resistance to Sawing". Plastic inserts shall be polyvinyl chloride conforming to the materials requirements of COE CRD-C 572.

PART 3 EXECUTION

3.1 PREPARATION FOR PLACING

Before commencing concrete placement, the following shall be performed. Surfaces to receive concrete shall be clean and free from frost, ice, mud, and water. Forms shall be in place, cleaned, coated, and adequately supported, in accordance with Section 03100 STRUCTURAL CONCRETE FORMWORK. Reinforcing steel shall be in place, cleaned, tied, and adequately supported, in accordance with Section 03200 CONCRETE REINFORCEMENT. Transporting and conveying equipment shall be in-place, ready for use, clean, and free of hardened concrete and foreign material. Equipment for consolidating concrete shall be at the placing site and in proper working order. Equipment and material for curing and for protecting concrete from weather or mechanical damage shall be at the placing site, in proper working condition and in sufficient amount for the entire placement. When hot, windy conditions during concreting appear probable, equipment and material shall be at the placing site to provide windbreaks, shading, fogging, or other action to prevent plastic shrinkage cracking or other damaging drying of the concrete.

3.1.1 Foundations

3.1.1.1 Concrete on Earth Foundations

Earth (subgrade, base, or subbase courses) surfaces upon which concrete is to be placed shall be clean, damp, and free from debris, frost, ice, and standing or running water. Prior to placement of concrete, the foundation shall be well drained and shall be satisfactorily graded and uniformly compacted.

3.1.2 Previously Placed Concrete

3.1.2.1 Preparation of Previously Placed Concrete

Concrete surfaces to which other concrete is to be bonded shall be abraded in an approved manner that will expose sound aggregate uniformly without damaging the concrete. Laitance and loose particles shall be removed. Surfaces shall be thoroughly washed and shall be moist but without free water for at least 12 hours before concrete is placed.

3.1.3 Vapor Barrier

Vapor barrier shall be provided beneath the interior on-grade concrete floor slabs. The greatest widths and lengths practicable shall be used to eliminate joints wherever possible. Joints shall be lapped a minimum of 300 mm. Torn, punctured, or damaged vapor barrier material shall be removed and new vapor barrier shall be provided prior to placing concrete. For minor repairs, patches may be made using laps of at least 300 mm. Lapped joints shall be sealed and edges patched with pressure-sensitive adhesive or tape not less than 50 mm wide and compatible with the membrane. Vapor barrier shall be placed directly on underlying subgrade, base course, or capillary water barrier, unless it consists of crushed material or large granular material which could puncture the vapor barrier. In this case, the surface shall be choked with a light layer of sand, as approved, before placing the vapor barrier. A 50 mm layer of compacted, clean concrete sand (fine aggregate) shall be placed on top of the vapor barrier before placing concrete. Concrete placement shall be controlled so as to prevent damage to the vapor barrier, or any covering sand.

3.1.4 Perimeter Insulation

Perimeter insulation shall be installed at locations indicated. Adhesive shall be used where insulation is applied to the interior surface of foundation walls and may be used for exterior application.

3.1.5 Embedded Items

Before placement of concrete, care shall be taken to determine that all embedded items are firmly and securely fastened in place as indicated on the drawings, or required. Conduit and other embedded items shall be clean and free of oil and other foreign matter such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Voids in sleeves, inserts, and anchor slots shall be filled temporarily with readily removable materials to prevent the entry of concrete into voids. Welding shall not be performed on embedded metals within 300 mm of the surface of the concrete. Tack welding shall not be performed on or to embedded items.

3.2 CONCRETE PRODUCTION

3.2.1 Batching, Mixing, and Transporting Concrete

Concrete shall be batched and mixed on site. Concrete shall be batched and mixed onsite or close to onsite; and shall conform to the following subparagraphs.

3.2.1.1 General

The batching plant shall be located on site in the general area indicated on the drawings. The batching, mixing and placing system shall have a capacity of at least 24 cubic meters per hour. The batching plant shall conform to the requirements of NRMCA CPMB 100 and as specified; however, rating plates attached to batch plant equipment are not required.

3.2.1.2 Batching Equipment

The batching controls shall be semiautomatic or automatic, as defined in NRMCA CPMB 100. A semiautomatic batching system shall be provided with interlocks such that the discharge device cannot be actuated until the

indicated material is within the applicable tolerance. The batching system shall be equipped with accurate recorder or recorders that meet the requirements of NRMCA CPMB 100. The weight of water and admixtures shall be recorded if batched by weight. Separate bins or compartments shall be provided for each size group of aggregate and type of cementitious material, to prevent intermingling at any time. Aggregates shall be weighed either in separate weigh batchers with individual scales or, provided the smallest size is batched first, cumulatively in one weigh batcher on one scale. Aggregate shall not be weighed in the same batcher with cementitious material. If both portland cement and other cementitious material are used, they may be batched cumulatively, provided that the portland cement is batched first. Water may be measured by weight or volume. Water shall not be weighed or measured cumulatively with another ingredient. Filling and discharging valves for the water metering or batching system shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. Piping for water and for admixtures shall be free from leaks and shall be properly valved to prevent backflow or siphoning. Admixtures shall be furnished as a liquid of suitable concentration for easy control of dispensing. An adjustable, accurate, mechanical device for measuring and dispensing each admixture shall be provided. Each admixture dispenser shall be interlocked with the batching and discharging operation of the water so that each admixture is separately batched and individually discharged automatically in a manner to obtain uniform distribution throughout the water as it is added to the batch in the specified mixing period. When use of truck mixers makes this requirement impractical, the admixture dispensers shall be interlocked with the sand batchers. Different admixtures shall not be combined prior to introduction in water and shall not be allowed to intermingle until in contact with the cement. Admixture dispensers shall have suitable devices to detect and indicate flow during dispensing or have a means for visual observation. The plant shall be arranged so as to facilitate the inspection of all operations at all times. Suitable facilities shall be provided for obtaining representative samples of aggregates from each bin or compartment, and for sampling and calibrating the dispensing of cementitious material, water, and admixtures. Filling ports for cementitious materials bins or silos shall be clearly marked with a permanent sign stating the contents.

3.2.1.3 Scales

The weighing equipment shall conform to the applicable requirements of CPMB Concrete Plant Standard, and of NIST HB 44, except that the accuracy shall be plus or minus 0.2 percent of scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring devices. The tests shall be made at the specified frequency in the presence of a Government inspector. The weighing equipment shall be arranged so that the plant operator can conveniently observe all dials or indicators.

3.2.1.4 Batching Tolerances

(A) Tolerances with Weighing Equipment

MATERIAL	PERCENT OF REQUIRED WEIGHT
Cementitious materials	0 to plus 2
Aggregate	plus or minus 2
Water	plus or minus 1
Chemical admixture	0 to plus 6

(B) Tolerances with Volumetric Equipment

For volumetric batching equipment used for water and admixtures, the following tolerances shall apply to the required volume of material being batched:

MATERIAL	PERCENT OF REQUIRED MATERIAL
Water:	plus or minus 1 percent
Chemical admixtures:	0 to plus 6 percent

3.2.1.5 Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched.

3.2.1.6 Concrete Mixers

Mixers shall be stationary mixers or truck mixers. Mixers shall be capable of combining the materials into a uniform mixture and of discharging this mixture without segregation. The mixers shall not be charged in excess of the capacity recommended by the manufacturer. The mixers shall be operated at the drum or mixing blade speed designated by the manufacturer. The mixers shall be maintained in satisfactory operating condition, and the mixer drums shall be kept free of hardened concrete. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired.

3.2.1.7 Stationary Mixers

Concrete plant mixers shall be drum-type mixers of tilting, nontilting, horizontal-shaft, or vertical-shaft type, or shall be pug mill type and shall be provided with an acceptable device to lock the discharge mechanism until the required mixing time has elapsed. The mixing time and uniformity shall conform to all the requirements in ASTM C 94 applicable to central-mixed concrete.

3.2.1.8 Truck Mixers

Truck mixers, the mixing of concrete therein, and concrete uniformity shall conform to the requirements of ASTM C 94. A truck mixer may be used either for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it is possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed. Water shall not be added at the placing site unless specifically approved; and in no case shall it exceed the specified w/c. Any such water shall be injected at the base of the mixer, not at the discharge end.

3.3 TRANSPORTING CONCRETE TO PROJECT SITE

Concrete shall be transported to the placing site in truck mixers, or by approved pumping equipment.

3.4 CONVEYING CONCRETE ON SITE

Concrete shall be conveyed from mixer or transporting unit to forms as rapidly as possible and within the time interval specified by methods which will prevent segregation or loss of ingredients using following equipment. Conveying equipment shall be cleaned before each placement.

3.4.1 Buckets

The interior hopper slope shall be not less than 58 degrees from the horizontal, the minimum dimension of the clear gate opening shall be at least 5 times the nominal maximum-size aggregate, and the area of the gate opening shall not be less than 0.2 square meters.The maximum dimension of the gate opening shall not be greater than twice the minimum dimension. The bucket gates shall be essentially grout tight when closed and may be manually, pneumatically, or hydraulically operated except that buckets larger than 1.5 cubic meters shall not be manually operated. The design of the bucket shall provide means for positive regulation of the amount and rate of deposit of concrete in each dumping position.

3.4.2 Transfer Hoppers

Concrete may be charged into nonagitating hoppers for transfer to other conveying devices. Transfer hoppers shall be capable of receiving concrete directly from delivery vehicles and shall have conical-shaped discharge features. The transfer hopper shall be equipped with a hydraulically operated gate and with a means of external vibration to effect complete discharge. Concrete shall not be held in nonagitating transfer hoppers more than 30 minutes.

3.4.3 Trucks

Truck mixers operating at agitating speed or truck agitators used for transporting plant-mixed concrete shall conform to the requirements of ASTM C 94. Nonagitating equipment shall be used only for transporting plant-mixed concrete over a smooth road and when the hauling time is less than 15 minutes. Bodies of nonagitating equipment shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

3.4.4 Chutes

When concrete can be placed directly from a truck mixer, agitator, or nonagitating equipment, the chutes normally attached to this equipment by the manufacturer may be used. A discharge deflector shall be used when required by the Contracting Officer. Separate chutes and other similar equipment will not be permitted for conveying concrete.

3.4.5 Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer to final place of deposit without segregation of

ingredients or loss of mortar and shall be provided with positive means, such as discharge baffle or hopper , for preventing segregation of the concrete at the transfer points and the point of placing. Belt conveyors shall be constructed such that the idler spacing shall not exceed 900 mm. The belt speed shall be a minimum of 90 meters per minute and a maximum of 225 meters per minute. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the conveyor shall discharge concrete into a pipe or elephant truck that is long enough to extend through the reinforcing bars.

3.4.6 Concrete Pumps

Concrete may be conveyed by positive displacement pump when approved. The pumping equipment shall be piston or squeeze pressure type; pneumatic placing equipment shall not be used. The pipeline shall be rigid steel pipe or heavy-duty flexible hose. The inside diameter of the pipe shall be at least 3 times the nominal maximum-size coarse aggregate in the concrete mixture to be pumped but not less than 100 mm. Aluminum pipe shall not be used.

3.5 PLACING CONCRETE

Mixed concrete shall be discharged within 1-1/2 hours or before the mixer drum has revolved 300 revolutions, whichever comes first after the introduction of the mixing water to the cement and aggregates. When the concrete temperature exceeds 30 degrees C, the time shall be reduced to 45 minutes. Concrete shall be placed within 15 minutes after it has been discharged from the transporting unit. Concrete shall be handled from mixer or transporting unit to forms in a continuous manner until the approved unit of operation is completed. Adequate scaffolding, ramps and walkways shall be provided so that personnel and equipment are not supported by in-place reinforcement. Placing will not be permitted when the sun, heat, wind, or limitations of facilities furnished by the Contractor prevent proper consolidation, finishing and curing. Sufficient placing capacity shall be provided so that concrete can be kept free of cold joints.

3.5.1 Depositing Concrete

Concrete shall be deposited as close as possible to its final position in the forms, and there shall be no vertical drop greater than 1.5 meters except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively consolidated in horizontal layers not more than 300 mm thick, except that all slabs shall be placed in a single layer. Concrete to receive other construction shall be screeded to the proper level. Concrete shall be deposited continuously in one layer or in layers so that fresh concrete is deposited on in-place concrete that is still plastic. Fresh concrete shall not be deposited on concrete that has hardened sufficiently to cause formation of seams or planes of weakness within the section. Concrete that has surface dried, partially hardened, or contains foreign material shall not be used. When temporary spreaders are used in the forms, the spreaders shall be removed as their service becomes unnecessary. Concrete shall not be placed in slabs over columns and walls until concrete in columns and walls has been in-place at least two hours or until the concrete begins to lose its plasticity. Concrete for beams, girders, brackets, column capitals, haunches, and drop panels shall be placed at the same time as concrete for adjoining slabs.

3.5.2 Consolidation

Immediately after placing, each layer of concrete shall be consolidated by internal vibrators, except for slabs 100 mm thick or less. The vibrators shall at all times be adequate in effectiveness and number to properly consolidate the concrete; a spare vibrator shall be kept at the jobsite during all concrete placing operations. The vibrators shall have a frequency of not less than 10,000 vibrations per minute, an amplitude of at least 0.6 mm, and the head diameter shall be appropriate for the structural member and the concrete mixture being placed. Vibrators shall be inserted vertically at uniform spacing over the area of placement. The distance between insertions shall be approximately 1-1/2 times the radius of action of the vibrator so that the area being vibrated will overlap the adjacent just-vibrated area by a reasonable amount. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm into the preceding layer if there is such. Vibrator shall be held stationary until the concrete is consolidated and then vertically withdrawn slowly while operating. Form vibrators shall not be used unless specifically approved and unless forms are constructed to withstand their use. Vibrators shall not be used to move concrete within the forms. Slabs 100 mm and less in thickness shall be consolidated by properly designed vibrating screeds or other approved technique. Excessive vibration of lightweight concrete resulting in segration or flotation of coarse aggregate shall be prevented. Frequency and amplitude of vibrators shall be determined in accordance with COE CRD-C 521. Grate tampers ("jitterbugs") shall not be used.

3.5.3 Hot Weather Requirements

When the ambient temperature during concrete placing is expected to exceed 30 degrees C, the concrete shall be placed and finished with procedures previously submitted and as specified herein. The concrete temperature at time of delivery to the forms shall not exceed the temperature shown in the table below when measured in accordance with ASTM C 1064/C 1064M. Cooling of the mixing water or aggregates or placing concrete in the cooler part of the day may be required to obtain an adequate placing temperature. A retarder may be used, as approved, to facilitate placing and finishing. Steel forms and reinforcements shall be cooled as approved prior to concrete placement when steel temperatures are greater than 49 degrees C. Conveying and placing equipment shall be cooled if necessary to maintain proper concrete-placing temperature.

Maximum Allowable Concrete Placing Temperature

Relative Humidity, Percent, During Time of Concrete Placement	Maximum Allowable Concrete Temperature Degrees
Greater than 60	33 C
40-60	30 C
Less than 40	27 C

3.5.4 Prevention of Plastic Shrinkage Cracking

During hot weather with low humidity, and particularly with appreciable wind, as well as interior placements when space heaters produce low humidity, the Contractor shall be alert to the tendency for plastic shrinkage cracks to develop and shall institute measures to prevent this.

Particular care shall be taken if plastic shrinkage cracking is potentially imminent and especially if it has developed during a previous placement. Periods of high potential for plastic shrinkage cracking can be anticipated by use of Fig. 2.1.5 of ACI 305R. In addition the concrete placement shall be further protected by erecting shades and windbreaks and by applying fog sprays of water, sprinkling, ponding or wet covering. Plastic shrinkage cracks that occur shall be filled by injection of epoxy resin as directed, after the concrete hardens. Plastic shrinkage cracks shall never be troweled over or filled with slurry.

3.5.5 Placing Concrete in Congested Areas

Special care shall be used to ensure complete filling of the forms, elimination of all voids, and complete consolidation of the concrete when placing concrete in areas congested with reinforcing bars, embedded items, waterstops and other tight spacing. An appropriate concrete mixture shall be used, and the nominal maximum size of aggregate (NMSA) shall meet the specified criteria when evaluated for the congested area. Vibrators with heads of a size appropriate for the clearances available shall be used, and the consolidation operation shall be closely supervised to ensure complete and thorough consolidation at all points. Where necessary, splices of reinforcing bars shall be alternated to reduce congestion. Where two mats of closely spaced reinforcing are required, the bars in each mat shall be placed in matching alignment to reduce congestion. Reinforcing bars may be temporarily crowded to one side during concrete placement provided they are returned to exact required location before concrete placement and consolidation are completed.

3.5.6 Placing Flowable Concrete

If a plasticizing admixture conforming to ASTM C 1017 is used or if a Type F or G high range water reducing admixture is permitted to increase the slump, the concrete shall meet all requirements of paragraph GENERAL REQUIREMENTS in PART 1. Extreme care shall be used in conveying and placing the concrete to avoid segregation. Consolidation and finishing shall meet all requirements of paragraphs Placing Concrete, Finishing Formed Surfaces, and Finishing Unformed Surfaces. No relaxation of requirements to accommodate flowable concrete will be permitted.

3.6 JOINTS

Joints shall be located and constructed as indicated or approved. Joints not indicated on the drawings shall be located and constructed to minimize the impact on the strength of the structure. In general, such joints shall be located near the middle of the spans of supported slabs, beams, and girders unless a beam intersects a girder at this point, in which case the joint in the girder shall be offset a distance equal to twice the width of the beam. Joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and at the tops of footings or floor slabs, unless otherwise approved. Joints shall be perpendicular to the main reinforcement. All reinforcement shall be continued across joints; except that reinforcement or other fixed metal items shall not be continuous through expansion joints, or through construction or contraction joints in slabs on grade. Reinforcement shall be 50 mm clear from each joint. Except where otherwise indicated, construction joints between interior slabs on grade and vertical surfaces shall consist of 1.5 kg per square meter asphalt-saturated felt, extending for the full depth of the slab. The perimeters of the slabs shall be free of fins, rough edges, spalling, or other unsightly appearance. Reservoir for sealant for construction and

contraction joints in slabs shall be formed to the dimensions shown on the drawings by removing snap-out joint-forming inserts, by sawing sawable inserts, or by sawing to widen the top portion of sawed joints. Joints to be sealed shall be cleaned and sealed as indicated and in accordance with Section 07900 JOINT SEALING.

3.6.1 Construction Joints

For concrete other than slabs on grade, construction joints shall be located so that the unit of operation does not exceed 7.5 meters. Concrete shall be placed continuously so that each unit is monolithic in construction. Fresh concrete shall not be placed against adjacent hardened concrete until it is at least 24 hours old. Construction joints shall be located as indicated or approved. Where concrete work is interrupted by weather, end of work shift or other similar type of delay, location and type of construction joint shall be subject to approval of the Contracting Officer. Unless otherwise indicated and except for slabs on grade, reinforcing steel shall extend through construction joints. Construction joints in slabs on grade shall be keyed or doweled as shown. Concrete columns, walls, or piers shall be in place at least 2 hours, or until the concrete begins to lose its plasticity, before placing concrete for beams, girders, or slabs thereon. In walls having door or window openings, lifts shall terminate at the top and bottom of the opening. Other lifts shall terminate at such levels as to conform to structural requirements or architectural details. Where horizontal construction joints in walls or columns are required, a strip of 25 mm square-edge lumber, bevelled and oiled to facilitate removal, shall be tacked to the inside of the forms at the construction joint. Concrete shall be placed to a point 25 mm above the underside of the strip. The strip shall be removed 1 hour after the concrete has been placed, and any irregularities in the joint line shall be leveled off with a wood float, and all laitance shall be removed. Prior to placing additional concrete, horizontal construction joints shall be prepared as specified in paragraph Previously Placed Concrete.

3.6.2 Contraction Joints in Slabs on Grade

Contraction joints shall be located and detailed as shown on the drawings. Contraction Joints shall be produced by forming a weakened plane in the concrete slab by sawing a continuous slot with a concrete saw. Regardless of method used to produce the weakened plane, it shall be 1/4 the depth of the slab thickness and between 3 and 5 mm wide. For saw-cut joints, cutting shall be timed properly with the set of the concrete. Cutting shall be started as soon as the concrete has hardened sufficiently to prevent ravelling of the edges of the saw cut. Cutting shall be completed before shrinkage stresses become sufficient to produce cracking. Reservoir for joint sealant shall be formed as previously specified.

3.6.3 Dowels and Tie Bars

Dowels and tie bars shall be installed at the locations shown on the drawings and to the details shown, using materials and procedures specified in Section 03200 CONCRETE REINFORCEMENT and herein. Conventional smooth "paving" dowels shall be installed in slabs using approved methods to hold the dowel in place during concreting within a maximum alignment tolerance of 1 mm in 100 mm. "Structural" type deformed bar dowels, or tie bars, shall be installed to meet the specified tolerances. Care shall be taken during placing adjacent to and around dowels and tie bars to ensure there is no displacement of the dowel or tie bar and that the concrete completely embeds the dowel or tie bar and is thoroughly consolidated.

3.7 FINISHING FORMED SURFACES

Forms, form materials, and form construction are specified in Section 03100 STRUCTURAL CONCRETE FORMWORK. Finishing of formed surfaces shall be as specified herein. Unless another type of architectural or special finish is specified, surfaces shall be left with the texture imparted by the forms except that defective surfaces shall be repaired. Unless painting of surfaces is required, uniform color of the concrete shall be maintained by use of only one mixture without changes in materials or proportions for any structure or portion of structure that requires a Class A. Except for major defects, as defined hereinafter, surface defects shall be repaired as specified herein within 24 hours after forms are removed. Repairs of the so-called "plaster-type" will not be permitted in any location. Tolerances of formed surfaces shall conform to the requirements of ACI 117/117R. These tolerances apply to the finished concrete surface, not to the forms themselves; forms shall be set true to line and grade. Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter shall be repaired as specified in paragraph Damp-Pack Mortar Repair. Defects whose surface diameter is greater than their depth shall be repaired as specified in paragraph Repair of Major Defects. Repairs shall be finished flush with adjacent surfaces and with the same surface texture. The cement used for all repairs shall be a blend of job cement with white cement proportioned so that the final color after curing and aging will be the same as the adjacent concrete. Concrete with excessive honeycomb, or other defects which affect the strength of the member, will be rejected. Repairs shall be demonstrated to be acceptable and free from cracks or loose or drummy areas at the completion of the contract and, for Class A, shall be inconspicuous. Repairs not meeting these requirements will be rejected and shall be replaced.

3.7.1 Class A Finish

Class A finish is required at all exposed surfaces unless noted otherwise. Fins, ravelings, and loose material shall be removed, all surface defects over 12 mm in diameter or more than 12 mm deep, shall be repaired and, except as otherwise indicated or as specified in Section 03100 STRUCTURAL CONCRETE FORMWORK, holes left by removal of form ties shall be reamed and filled. Defects more than 12 mm in diameter shall be cut back to sound concrete, but in all cases at least 25 mm deep. The Contractor shall prepare a sample panel for approval (as specified in PART 1) before commencing repair, showing that the surface texture and color match will be attained. Metal tools shall not be used to finish repairs in Class A surfaces.

3.7.2 Class C and Class D Finish

Class C finish is required at all concealed surfaces and interior surfaces of the mechanical and electrical rooms. Class D finish is required at foundation surfaces against which backfill will be placed. Fins, ravelings, and loose material shall be removed, and, except as otherwise indicated or as specified in Section 03100 STRUCTURAL CONCRETE FORMWORK, holes left by removal of form ties shall be reamed and filled. Honeycomb and other defects more than 12 mm deep or more than 50 mm in diameter shall be repaired. Defects more than 50 mm in diameter shall be cut back to sound concrete, but in all cases at least 25 mm deep.

3.8 REPAIRS

3.8.1 Damp-Pack Mortar Repair

Form tie holes requiring repair and other defects whose depth is at least as great as their surface diameter but not over 100 mm shall be repaired by the damp-pack mortar method. Form tie holes shall be reamed and other similar defects shall be cut out to sound concrete. The void shall then be thoroughly cleaned, thoroughly wetted, brush-coated with a thin coat of neat cement grout and filled with mortar. Mortar shall be a stiff mix of 1 part portland cement to 2 parts fine aggregate passing the 1.18 mm sieve, and minimum amount of water. Only sufficient water shall be used to produce a mortar which, when used, will stick together on being molded into a ball by a slight pressure of the hands and will not exude water but will leave the hands damp. Mortar shall be mixed and allowed to stand for 30 to 45 minutes before use with remixing performed immediately prior to use. Mortar shall be thoroughly tamped in place in thin layers using a hammer and hardwood block. Holes passing entirely through walls shall be completely filled from the inside face by forcing mortar through to the outside face. All holes shall be packed full. Damp-pack repairs shall be moist cured for at least 48 hours.

3.8.2 Repair of Major Defects

Major defects will be considered to be those more than 12 mm deep or, for Class A and B finishes, more than 12 mm in diameter and, for Class C and D finishes, more than 50 mm in diameter. Also included are any defects of any kind whose depth is over 100 mm or whose surface diameter is greater than their depth. Major defects shall be repaired as specified below.

3.8.2.1 Surface Application of Mortar Repair

Defective concrete shall be removed, and removal shall extend into completely sound concrete. Approved equipment and procedures which will not cause cracking or microcracking of the sound concrete shall be used. If reinforcement is encountered, concrete shall be removed so as to expose the reinforcement for at least 50 mm on all sides. All such defective areas greater than 7800 square mm shall be outlined by saw cuts at least 25 mm deep. Defective areas less than 7800 square mm shall be outlined by a 25 mm deep cut with a core drill in lieu of sawing. All saw cuts shall be straight lines in a rectangular pattern in line with the formwork panels. After concrete removal, the surface shall be thoroughly cleaned by high pressure washing to remove all loose material. Surfaces shall be kept continually saturated for the first 12 of the 24 hours immediately before placing mortar and shall be damp but not wet at the time of commencing mortar placement. The Contractor, at his option, may use either hand-placed mortar or mortar placed with a mortar gun. If hand-placed mortar is used, the edges of the cut shall be perpendicular to the surface of the concrete. The prepared area shall be brush-coated with a thin coat of neat cement grout. The repair shall then be made using a stiff mortar, preshrunk by allowing the mixed mortar to stand for 30 to 45 minutes and then remixed, thoroughly tamped into place in thin layers. If hand-placed mortar is used, the Contractor shall test each repair area for drumminess by firm tapping with a hammer and shall inspect for cracks, both in the presence of the Contracting Officer's representative, immediately before completion of the contract, and shall replace any showing drumminess or cracking. If mortar placed with a mortar gun is used, the gun shall be a small compressed air-operated gun to which the mortar is slowly hand fed and which applies the mortar to the surface as a high-pressure stream, as approved. Repairs made using shotcrete equipment will not be accepted. The mortar used shall be the same mortar as specified for damp-pack mortar

repair. If gun-placed mortar is used, the edges of the cut shall be beveled toward the center at a slope of 1:1. All surface applied mortar repairs shall be continuously moist cured for at least 7 days. Moist curing shall consist of several layers of saturated burlap applied to the surface immediately after placement is complete and covered with polyethylene sheeting, all held closely in place by a sheet of plywood or similar material rigidly braced against it. Burlap shall be kept continually wet.

3.8.3 Resinous and Latex Material Repair

In lieu of the portland cement bonding coats specified above, an epoxy resin or a latex bonding agent may be used.

3.9 FINISHING UNFORMED SURFACES

The finish of all unformed surfaces shall meet the requirements of paragraph Tolerances in PART 1, when tested as specified herein.

3.9.1 General

The ambient temperature of spaces adjacent to unformed surfaces being finished and of the base on which concrete will be placed shall be not less than 10 degrees C. In hot weather all requirements of paragraphs Hot Weather Requirements and Prevention of Plastic Shrinkage Cracking shall be met. Unformed surfaces that are not to be covered by additional concrete or backfill shall have a float finish, with additional finishing as specified below, and shall be true to the elevation shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown on the drawings, properly consolidated, and left true and regular. Unless otherwise shown on the drawings, exterior surfaces shall be sloped for drainage, as directed. Where drains are provided, interior floors shall be evenly sloped to the drains. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Grate tampers or "jitterbugs" shall not be used for any surfaces. The dusting of surfaces with dry cement or other materials or the addition of any water during finishing shall not be permitted. If bleedwater is present prior to finishing, the excess water shall be carefully dragged off or removed by absorption with porous materials such as burlap. During finishing operations, extreme care shall be taken to prevent over finishing or working water into the surface; this can cause "crazing" (surface shrinkage cracks which appear after hardening) of the surface. Any slabs with surfaces which exhibit significant crazing shall be removed and replaced. During finishing operations, surfaces shall be checked with a 10 foot straightedge, applied in both directions at regular intervals while the concrete is still plastic, to detect high or low areas.

3.9.2 Rough Slab Finish

As a first finishing operation for unformed surfaces and as final finish receive a rough slab finish prepared as follows. Areas indicated on the drawings shall receive only a rough slab finish. The concrete shall be uniformly placed across the slab area, consolidated as previously specified, and then screeded with straightedge strikeoffs immediately after consolidation to bring the surface to the required finish level with no coarse aggregate visible. Side forms and screed rails shall be provided, rigidly supported, and set to exact line and grade. Allowable tolerances for finished surfaces apply only to the hardened concrete, not to forms or

screed rails. Forms and screed rails shall be set true to line and grade. "Wet screeds" shall not be used.

3.9.3 Floated Finish

Slabs to receive more than a rough slab finish shall next be given a wood float finish. Roof surfaces shall be given only a float finish. The screeding shall be followed immediately by darbying or bull floating before bleeding water is present, to bring the surface to a true, even plane. Then, after the concrete has stiffened so that it will withstand a man's weight without imprint of more than 6 mm and the water sheen has disappeared, it shall be floated to a true and even plane free of ridges. Floating shall be performed by use of suitable hand floats or power driven equipment. Sufficient pressure shall be used on the floats to bring a film of moisture to the surface. Hand floats shall be made of wood, magnesium, or aluminum. Concrete that exhibits stickiness shall be floated with a magnesium float. Care shall be taken to prevent over-finishing or incorporating water into the surface.

3.9.4 Troweled Finish

All interior floors, except where indicated otherwise, shall be given a trowel finish. After floating is complete and after the surface moisture has disappeared, unformed surfaces shall be steel-troweled to a smooth, even, dense finish, free from blemishes including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. Additional trowelings shall be performed, either by hand or machine until the surface has been troweled 2 times, with waiting period between each. Care shall be taken to prevent blistering and if such occurs, troweling shall immediately be stopped and operations and surfaces corrected. A final hard steel troweling shall be done by hand, with the trowel tipped, and using hard pressure, when the surface is at a point that the trowel will produce a ringing sound. The finished surface shall be thoroughly consolidated and shall be essentially free of trowel marks and be uniform in texture and appearance. The concrete mixture used for troweled finished areas shall be adjusted, if necessary, in order to provide sufficient fines (cementitious material and fine sand) to finish properly.

3.9.5 Non-Slip Finish

Non-slip floors shall be constructed in accordance with the following subparagraphs.

3.9.5.1 Broomed

Exterior walkways, ramps and hardstands shall be given a broomed finish. After floating, the surface shall be lightly steel troweled, and then carefully scored by pulling a hair coarse fiber push-type broom across the surface. Brooming shall be transverse to traffic or at right angles to the slope of the slab. After the end of the curing period, the surface shall be vigorously broomed with a coarse fiber broom to remove all loose or semi-detached particles.

3.9.6 Heavy Duty Floors

All interior refrigerated spaces shall have heavy duty floors constructed as follows:

3.9.6.1 General

Heavy duty floor shall be constructed by placing a heavy duty bonded topping. Concrete in the base slab shall be thoroughly hardened but not more than 30 hours old. The temperature of the fresh concrete topping shall not vary more than 5 degrees C plus or minus from the temperature of the base slab. The ambient temperature of the space adjacent to the concrete placement and of the base slab shall be between 10 and 30 degrees C.

3.9.6.2 Placing and Finishing

Concrete shall be placed, as nearly as practicable in final position, in a uniform layer. The overlay shall be placed and screeded slightly above the required finished grade, compacted by rolling with rollers weighing not less than 4.5 kg per linear 25 mm of roller width or by approved tamping equipment and finish screeded to established grade. Grid type tampers shall not be used. The concrete, while still green but sufficiently hardened to bear a person's weight without deep imprint, shall be floated to a true even plane with no coarse aggregate visible. Floating shall be performed with an approved disc-type mechanical float which has integral impact mechanism. The surface of the overlay shall then be left undisturbed until the concrete has hardened enough to prevent excess fines from being worked to the top. Joints shall be formed to match those in the base slab.

3.9.6.3 Curing and Protection

Concrete shall be maintained in a moist condition and shall be protected against rapid temperature change, mechanical injury, and injury from rain or flowing water, for a curing period of not less than 10 days. Concrete shall be maintained in a moist condition at temperatures above 10 and below 30 degrees C throughout the specified curing period. Concrete shall be protected from a temperature change greater than 3 degrees C per hour and from rapid drying for the first 24 hours following the removal of temperature protection. Curing activities shall begin as soon as free water has disappeared from the concrete surface after placing and finishing. Curing shall be moist curing accomplished by the following method. Surfaces shall be covered with a double layer of burlap, wetted before placing, and overlapped at least 150 mm. Burlap shall be kept continually wet and in intimate contact with the surface. Burlap shall be kept covered with a polyethylene sheeting at least 0.1 mm thick. All traffic shall be kept from the floor during the curing period and heavy traffic shall be kept off till 28-day age.

3.10 FLOOR HARDENER

Areas as indicated on the drawings shall be treated with floor hardener. Floor hardener shall be applied after the concrete has been cured and then air dried for 28 days. Three coats shall be applied, each the day after the preceding coat was applied. For the first application, 0.5 kg of the silocofluoride shall be dissolved in 4 liters of water. For subsequent applications, the solution shall be 1.0 kg of silicofluoride to each 4 liters of water. Floor should be mopped with clear water shortly after the preceding application has dried to remove encrusted salts. Proprietary hardeners shall be applied in accordance with the manufacturer's instructions. During application, area should be well ventilated. Precautions shall be taken when applying silicofluorides due to the toxicity of the salts. Any compound that contacts glass or aluminum should

be immediately removed with clear water.

3.11 EXTERIOR SLAB AND RELATED ITEMS

3.11.1 Pavements

Pavements shall be constructed where shown on the drawings. After forms are set and underlying material prepared as specified, the concrete shall be placed uniformly throughout the area and thoroughly vibrated. As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. The entire surface shall be tamped with the strike off, or consolidated with a vibrating screed, and this operation continued until the required compaction and reduction of internal and surface voids are accomplished. Care shall be taken to prevent bringing excess paste to the surface. Immediately following the final consolidation of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces. After finishing is completed but while the concrete is still plastic, minor irregularities and score marks in the pavement surface shall be eliminated by means of long-handled cutting straightedges. Straightedges shall be 3.75 m in length and shall be operated from the sides of the pavement and from bridges. A straightedge operated from the side of the pavement shall be equipped with a handle 1 m longer than one-half the width of the pavement. The surface shall then be tested for trueness with a 3.75 straightedge held in successive positions parallel and at right angles to the center line of the pavement, and the whole area covered as necessary to detect variations. The straightedge shall be advanced along the pavement in successive stages of not more than one-half the length of the straightedge. Depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. Projections above the required elevation shall also be struck off and refinished. The straightedge testing and finishing shall continue until the entire surface of the concrete is true. Before the surface sheen has disappeared and well before the concrete becomes nonplastic, the surface of the pavement shall be given a nonslip sandy surface texture by use of a burlap drag. A strip of clean, wet burlap from 1.0 to 1.5 m wide and 0.7 m longer than the pavement width shall be carefully pulled across the surface. Edges and joints shall be rounded with an edger having a radius of 3 mm. Curing shall be as specified.

3.11.2 Sidewalks

Concrete shall be 100 mm minimum thickness. Contraction joints shall be provided at 1.75 m spaces unless otherwise indicated. Contraction joints shall be cut 25 mm deep with a jointing tool after the surface has been finished. Transverse expansion joints 12 mm thick shall be provided at changes in direction and where sidewalk abuts curbs, steps, rigid pavement, or other similar structures. Sidewalks shall be given a lightly broomed finish. A transverse slope of 1 mm per 50 mm shall be provided, unless otherwise indicated. Variations in cross section shall be limited to 1 mm per 250 mm.

3.11.3 Curbs and Gutters

Concrete shall be formed, placed, and finished by hand using a properly shaped "mule" or constructed using a slipform machine specially designed for this work. Contraction joints shall be cut 75 mm deep with a jointing tool after the surface has been finished. Expansion joints (12 mm wide) shall be provided at 35 m maximum spacing unless otherwise indicated. Exposed surfaces shall be finished using a stiff bristled brush.

3.11.4 Pits and Trenches

Pits and trenches shall be constructed as indicated on the drawings. Bottoms and walls shall be placed monolithically or waterstops and keys, shall be provided as approved.

3.12 CURING AND PROTECTION

3.12.1 General

Concrete shall be cured by an approved method for the period of time given below:

Concrete with Type III cement	3 days
All other concrete	7 days

Immediately after placement, concrete shall be protected from premature drying, extremes in temperatures, rapid temperature change, mechanical injury and damage from rain and flowing water for the duration of the curing period. Air and forms in contact with concrete shall be maintained at a temperature above 10 degrees C for the first 3 days and at a temperature above 0 degrees C for the remainder of the specified curing period. Exhaust fumes from combustion heating units shall be vented to the outside of the enclosure, and heaters and ducts shall be placed and directed so as not to cause areas of overheating and drying of concrete surfaces or to create fire hazards. Materials and equipment needed for adequate curing and protection shall be available and at the site prior to placing concrete. No fire or excessive heat, including welding, shall be permitted near or in direct contact with the concrete at any time. Except as otherwise permitted by paragraph Membrane Forming Curing Compounds, moist curing shall be provided for any areas to receive floor hardener, any paint or other applied coating, or to which other concrete is to be bonded. Concrete containing silica fume shall be initially cured by fog misting during finishing, followed immediately by continuous moist curing. Except for plastic coated burlap, impervious sheeting alone shall not be used for curing.

3.12.2 Moist Curing

Concrete to be moist-cured shall be maintained continuously wet for the entire curing period, commencing immediately after finishing. If water or curing materials used stain or discolor concrete surfaces which are to be permanently exposed, the concrete surfaces shall be cleaned as approved. When wooden forms are left in place during curing, they shall be kept wet at all times. If steel forms are used in hot weather, nonsupporting vertical forms shall be broken loose from the concrete soon after the concrete hardens and curing water continually applied in this void. If the forms are removed before the end of the curing period, curing shall be carried out as on unformed surfaces, using suitable materials. Surfaces shall be cured by ponding, by continuous sprinkling, by continuously saturated burlap or cotton mats, or by continuously saturated plastic

coated burlap. Burlap and mats shall be clean and free from any contamination and shall be completely saturated before being placed on the concrete. The Contractor shall have an approved work system to ensure that moist curing is continuous 24 hours per day.

3.12.3 Membrane Forming Curing Compounds

Concrete may be cured with a nonpigmented curing compound containing a fugitive dye in lieu of moist curing. Membrane curing shall not be used on surfaces that are to receive any subsequent treatment depending on adhesion or bonding to the concrete, including surfaces to which a smooth finish is to be applied or other concrete to be bonded. However, a styrene acrylate or chlorinated rubber compound meeting ASTM C 309, Class B requirements, may be used for surfaces which are to be painted or are to receive bituminous roofing or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, waterproofing or flooring specified. Membrane curing compound shall not be used on surfaces that are maintained at curing temperatures with free steam. Curing compound shall be applied to formed surfaces immediately after the forms are removed and prior to any patching or other surface treatment except the cleaning of loose sand, mortar, and debris from the surface. All surfaces shall be thoroughly moistened with water. Curing compound shall be applied to slab surfaces as soon as the bleeding water has disappeared, with the tops of joints being temporarily sealed to prevent entry of the compound and to prevent moisture loss during the curing period. The curing compound shall be applied in a two-coat continuous operation by approved motorized power-spraying equipment operating at a minimum pressure of 500 kPa, at a uniform coverage of not more than 10 cubic meters per L for each coat, and the second coat shall be applied perpendicular to the first coat. Concrete surfaces which have been subjected to rainfall within 3 hours after curing compound has been applied shall be resprayed by the method and at the coverage specified. Surfaces on which clear compound is used shall be shaded from direct rays of the sun for the first 3 days. Surfaces coated with curing compound shall be kept free of foot and vehicular traffic, and from other sources of abrasion and contamination during the curing period.

3.12.4 Impervious Sheeting

Impervious-sheet curing shall only be used on horizontal or nearly horizontal surfaces. Surfaces shall be thoroughly wetted and be completely covered with the sheeting. Sheeting shall be at least 450 mm wider than the concrete surface to be covered. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 300 mm and securely weighted down or shall be lapped not less than 100 mm and taped to form a continuous cover with completely closed joints. The sheet shall be weighted to prevent displacement so that it remains in contact with the concrete during the specified length of curing. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3.12.5 Ponding or Immersion

Concrete shall be continually immersed throughout the curing period. Water shall not be more than 10 degrees C less than the temperature of the concrete.

3.13 SETTING BASE PLATES AND BEARING PLATES

After being properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be set to the proper line and elevation with damp-pack bedding mortar, except where nonshrink grout is indicated. The thickness of the mortar or grout shall be approximately 1/24 the width of the plate, but not less than 20 mm. Concrete and metal surfaces in contact with grout shall be clean and free of oil and grease, and concrete surfaces in contact with grout shall be damp and free of laitance when grout is placed. Nonshrink grout shall be used as indicated on the drawings.

3.13.1 Damp-Pack Bedding Mortar

Damp-pack bedding mortar shall consist of 1 part cement and 2-1/2 parts fine aggregate having water content such that a mass of mortar tightly squeezed in the hand will retain its shape but will crumble when disturbed. The space between the top of the concrete and bottom of the bearing plate or base shall be packed with the bedding mortar by tamping or ramming with a bar or rod until it is completely filled.

3.13.2 Nonshrink Grout

Nonshrink grout shall be a ready-mixed material requiring only the addition of water. Water content shall be the minimum that will provide a flowable mixture and completely fill the space to be grouted without segregation, bleeding, or reduction of strength.

3.13.2.1 Mixing and Placing of Nonshrink Grout

Mixing and placing shall be in conformance with the material manufacturer's instructions and as specified therein. Ingredients shall be thoroughly dry-mixed before adding water. After adding water, the batch shall be mixed for 3 minutes. Batches shall be of size to allow continuous placement of freshly mixed grout. Grout not used within 30 minutes after mixing shall be discarded. The space between the top of the concrete or machinery-bearing surface and the plate shall be filled solid with the grout. Forms shall be of wood or other equally suitable material for completely retaining the grout on all sides and on top and shall be removed after the grout has set. The placed grout shall be carefully worked by rodding or other means to eliminate voids; however, overworking and breakdown of the initial set shall be avoided. Grout shall not be retempered or subjected to vibration from any source. Where clearances are unusually small, placement shall be under pressure with a grout pump. Temperature of the grout, and of surfaces receiving the grout, shall be maintained at 18 to 30 degrees C until after setting.

3.13.2.2 Treatment of Exposed Surfaces

For metal-oxidizing nonshrink grout, exposed surfaces shall be cut back 25 mm and immediately covered with a parge coat of mortar consisting of 1 part portland cement and 2-1/2 parts fine aggregate by weight, with sufficient water to make a plastic mixture. The parge coat shall have a smooth finish. For other mortars or grouts, exposed surfaces shall have a smooth-dense finish and be left untreated. Curing shall comply with paragraph CURING AND PROTECTION.

3.14 TESTING AND INSPECTION FOR CONTRACTOR QUALITY CONTROL

The Contractor shall perform the inspection and tests described below and,

based upon the results of these inspections and tests, shall take the action required and shall submit specified reports. When, in the opinion of the Contracting Officer, the concreting operation is out of control, concrete placement shall cease and the operation shall be corrected. The laboratory performing the tests shall be onsite and shall conform with ASTM C 1077. Materials may be subjected to check testing by the Government from samples obtained at the manufacturer, at transfer points, or at the project site.

3.14.1 Grading and Corrective Action

3.14.1.1 Fine Aggregate

At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. When the amount passing on any sieve is outside the specification limits, the fine aggregate shall be immediately resampled and retested. If there is another failure on any sieve, the fact shall immediately reported to the Contracting Officer, concreting shall be stopped, and immediate steps taken to correct the grading.

3.14.1.2 Coarse Aggregate

At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported to the Contracting Officer. Where two consecutive averages of 5 tests are outside specification limits, the operation shall be considered out of control and shall be reported to the Contracting Officer. Concreting shall be stopped and immediate steps shall be taken to correct the grading.

3.14.2 Quality of Aggregates

Thirty days prior to the start of concrete placement, the Contractor shall perform all tests for aggregate quality required by ASTM C 33. In addition, after the start of concrete placement, the Contractor shall perform tests for aggregate quality at least every three months, and when the source of aggregate or aggregate quality changes. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

3.14.3 Scales, Batching and Recording

The accuracy of the scales shall be checked by test weights prior to start of concrete operations and at least once every three months. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors. Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. At the same time, the Contractor shall test and ensure that the devices for dispensing admixtures are operating properly and accurately. When either the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

3.14.4 Batch-Plant Control

The measurement of concrete materials including cementitious materials, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter for each class of concrete batched during each day's plant operation.

3.14.5 Concrete Mixture

a. Air Content Testing. Air content tests shall be made when test specimens are fabricated. In addition, at least two tests for air content shall be made on randomly selected batches of each separate concrete mixture produced during each 8-hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Tests shall be made in accordance with ASTM C 231 for normal weight concrete and ASTM C 173 for lightweight concrete. Test results shall be plotted on control charts which shall at all times be readily available to the Government and shall be submitted weekly. Copies of the current control charts shall be kept in the field by testing crews and results plotted as tests are made. When a single test result reaches either the upper or lower action limit, a second test shall immediately be made. The results of the two tests shall be averaged and this average used as the air content of the batch to plot on both the air content and the control chart for range, and for determining need for any remedial action. The result of each test, or average as noted in the previous sentence, shall be plotted on a separate control chart for each mixture on which an "average line" is set at the midpoint of the specified air content range from paragraph Air Entrainment. An upper warning limit and a lower warning limit line shall be set 1.0 percentage point above and below the average line, respectively. An upper action limit and a lower action limit line shall be set 1.5 percentage points above and below the average line, respectively. The range between each two consecutive tests shall be plotted on a secondary control chart for range where an upper warning limit is set at 2.0 percentage points and an upper action limit is set at 3.0

percentage points. Samples for air content may be taken at the mixer, however, the Contractor is responsible for delivering the concrete to the placement site at the stipulated air content. If the Contractor's materials or transportation methods cause air content loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer, and the air content at the mixer controlled as directed.

b. Air Content Corrective Action. Whenever points on the control chart for percent air reach either warning limit, an adjustment shall immediately be made in the amount of air-entraining admixture batched. As soon as practical after each adjustment, another test shall be made to verify the result of the adjustment. Whenever a point on the secondary control chart for range reaches the warning limit, the admixture dispenser shall be recalibrated to ensure that it is operating accurately and with good reproducibility. Whenever a point on either control chart reaches an action limit line, the air content shall be considered out of control and the concreting operation shall immediately be halted until the air content is under control. Additional air content tests shall be made when concreting is restarted.

c. Slump Testing. In addition to slump tests which shall be made when test specimens are fabricated, at least four slump tests shall be made on randomly selected batches in accordance with ASTM C 143 for each separate concrete mixture produced during each 8-hour or less period of concrete production each day. Also, additional tests shall be made when excessive variation in workability is reported by the placing foreman or Government inspector. Test results shall be plotted on control charts which shall at all times be readily available to the Government and shall be submitted weekly. Copies of the current control charts shall be kept in the field by testing crews and results plotted as tests are made. When a single slump test reaches or goes beyond either the upper or lower action limit, a second test shall immediately be made. The results of the two tests shall be averaged and this average used as the slump of the batch to plot on both the control charts for slump and the chart for range, and for determining need for any remedial action. Limits shall be set on separate control charts for slump for each type of mixture. The upper warning limit shall be set at 12.5 mm below the maximum allowable slump specified in paragraph Slump in PART 1 for each type of concrete and an upper action limit line and lower action limit line shall be set at the maximum and minimum allowable slumps, respectively, as specified in the same paragraph. The range between each consecutive slump test for each type of mixture shall be plotted on a single control chart for range on which an upper action limit is set at 50 mm. Samples for slump shall be taken at the mixer. However, the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between the mixer and the placement, correlation samples shall be taken at the placement site as required by the Contracting Officer, and the slump at the mixer controlled as directed.

d. Slump Corrective Action. Whenever points on the control charts for slump reach the upper warning limit, an adjustment shall

immediately be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount allowed by the maximum w/c ratio specified, based on aggregates which are in a saturated surface dry condition. When a single slump reaches the upper or lower action limit, no further concrete shall be delivered to the placing site until proper adjustments have been made. Immediately after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range at or above the upper action limit, the concreting operation shall immediately be halted, and the Contractor shall take appropriate steps to bring the slump under control. Additional slump tests shall be made as directed.

e. Temperature. The temperature of the concrete shall be measured when compressive strength specimens are fabricated. Measurement shall be in accordance with ASTM C 1064/C 1064M. The temperature shall be reported along with the compressive strength data.

f. Strength Specimens. At least one set of test specimens shall be made, for compressive or flexural strength as appropriate, on each different concrete mixture placed during the day for each 380 cubic meters or portion thereof of that concrete mixture placed each day. Additional sets of test specimens shall be made, as directed by the Contracting Officer, when the mixture proportions are changed or when low strengths have been detected. A truly random (not haphazard) sampling plan shall be developed by the Contractor and approved by the Contracting Officer prior to the start of construction. The plan shall assure that sampling is done in a completely random and unbiased manner. A set of test specimens for concrete with a 28-day specified strength per paragraph Strength Requirements in PART 1 shall consist of four specimens, two to be tested at 7 days and two at 28 days. A set of test specimens for concrete with a 90-day strength per the same paragraph shall consist of six specimens, two tested at 7 days, two at 28 days, and two at 90 days. Test specimens shall be molded and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39 for test cylinders and ASTM C 78 for test beams. Results of all strength tests shall be reported immediately to the Contracting Officer. Quality control charts shall be kept for individual strength "tests", ("test" as defined in paragraph Strength Requirements in PART 1) moving average of last 3 "tests" for strength, and moving average for range for the last 3 "tests" for each mixture. The charts shall be similar to those found in ACI 214.3R.

3.14.6 Inspection Before Placing

Foundations, construction joints, forms, and embedded items shall be inspected by the Contractor in sufficient time prior to each concrete placement in order to certify to the Contracting Officer that they are ready to receive concrete. The results of each inspection shall be reported in writing.

3.14.7 Placing

The placing foreman shall supervise placing operations, shall determine

that the correct quality of concrete or grout is placed in each location as specified and as directed by the Contracting Officer, and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume placed, and method of placement. The placing foreman shall not permit batching and placing to begin until it has been verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

3.14.8 Vibrators

The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521 prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head, and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing. Any vibrator not meeting the requirements of paragraph Consolidation, shall be immediately removed from service and repaired or replaced.

3.14.9 Curing Inspection

a. Moist Curing Inspections. At least once each shift, and not less than twice per day on both work and non-work days, an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

b. Moist Curing Corrective Action. When a daily inspection report lists an area of inadequate curing, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by 1 day.

c. Membrane Curing Inspection. No curing compound shall be applied until the Contractor has verified that the compound is properly mixed and ready for spraying. At the end of each operation, the Contractor shall estimate the quantity of compound used by measurement of the container and the area of concrete surface covered, shall compute the rate of coverage in square meters per Liter, and shall note whether or not coverage is uniform.

d. Membrane Curing Corrective Action. When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

e. Sheet Curing Inspection. At least once each shift and once per day on non-work days, an inspection shall be made of all areas being cured using impervious sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

f. Sheet Curing Corrective Action. When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by 1 day.

3.14.10 Mixer Uniformity

a. Stationary Mixers. Prior to the start of concrete placing and once every 6 months when concrete is being placed, or once for every 60,000 cubic meters of concrete placed, whichever results in the shortest time interval, uniformity of concrete mixing shall be determined in accordance with ASTM C 94.

b. Truck Mixers. Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete mixing shall be determined in accordance with ASTM C 94. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory.

c. Mixer Uniformity Corrective Action. When a mixer fails to meet mixer uniformity requirements, either the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

3.14.11 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold-weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

-- End of Section --

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SECTION 03411

PLANT-PRECAST STRUCTURAL CONCRETE, BEAMS AND COLUMNS

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SECTION 03411

PLANT-PRECAST STRUCTURAL CONCRETE, BEAMS AND COLUMNS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO SSHB-I-14	Highway Bridges-Division I-Section 14: Bearings

ACI INTERNATIONAL (ACI)

ACI 304R	(1989) Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	(1991) Hot Weather Concreting
ACI 309R	(1996) Consolidation of Concrete
ACI 318/318M	(1995) Building Code Requirements for Structural Concrete

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A135.4	(1995) Basic Hardboard

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 27/A 27M	(1995) Steel Castings, Carbon, for General Application
ASTM A 36/A 36M	(1996) Carbon Structural Steel
ASTM A 47M	(1990) Ferritic Malleable Iron Castings (Metric)
ASTM A 123/A 123M	(1997; Rev. A) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(1995) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(1994) Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 563M	(1996) Carbon and Alloy Steel Nuts (Metric)
ASTM A 615/A 615M	(1996; Rev. A) Deformed and Plain

	Billet-Steel Bars for Concrete Reinforcement
ASTM A 706/A 706M	(1996; Rev. B) Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 767/A 767M	(2000) Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
ASTM A 780	(1993; Rev. A) Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A 884/A 884M	(2001) Epoxy-Coated Steel Wire and Welded Wire Fabric Reinforcement
ASTM A 934/A 934M	(2001) Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM C 33	(1997) Concrete Aggregates
ASTM C 94	(1997) Ready-Mixed Concrete
ASTM C 260	(1995) Air-Entraining Admixtures for Concrete
ASTM C 494	(1992) Chemical Admixtures for Concrete
ASTM C 1107	(1997) Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
ASTM F 844	(1990) Washers, Steel, Plain (Flat), Unhardened for General Use

AMERICAN WELDING SOCIETY (AWS)

AWS D1.4	(1998) Structural Welding Code - Reinforcing Steel

PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)

PCI MNL-116	(1985) Quality Control for Plants and Production of Precast Prestressed Concrete Products
PCI MNL-120	(1992) Design Handbook - Precast and Prestressed Concrete

1.2 PRECAST MEMBERS

The work includes the provision of precast non-prestressed concrete herein referred to as precast members. Precast members shall be the product of a manufacturer specializing in the production of precast concrete members. In the ACI publications, the advisory provisions shall be considered to be mandatory, as though the word "shall" has been substituted for "should" wherever it appears; reference to the "Building Official," the "Structural Engineer" and the "Architect/Engineer" shall be interpreted to mean the Contracting Officer.

1.3 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Drawings of precast members; G, AE

SD-03 Product Data

Anchorage and lifting inserts and devices

Bearing pads

SD-05 Design Data

Precast concrete members design calculations; G, AE

Concrete mix design

SD-06 Test Reports

Contractor-furnished mix design

Submit copies of test reports showing that the mix has been successfully tested to produce concrete with the properties specified and will be suitable for the job conditions. Obtain approval before concrete placement.

SD-07 Certificates

Fabrication

Submit quality control procedures established in accordance with PCI MNL-116 by the precast manufacturer.

SD-11 Closeout Submittals

Concrete batch ticket information

1.4 QUALITY CONTROL

1.4.1 Precast Concrete Member Design

ACI 318/318M and the PCI MNL-120. Design precast members (including connections) for the design load conditions and spans indicated, and for additional loads imposed by openings and supports of the work of other trades. Design precast members for handling without cracking in accordance with the PCI MNL-120.

1.4.2 PCI Quality Certifications

PCI MNL-116. At the precast manufacturer's option, in lieu of core samples, ACI 318/318M, full scale load tests may be performed. Perform on randomly selected members, as directed by the Contracting Officer.

1.4.2.1 Product Quality Control

PCI MNL-116 for PCI enrolled plants. Where precast members are manufactured by specialists in plants not currently enrolled in the PCI "Quality Control Program," provide a product quality control system in accordance with PCI MNL-116 and perform concrete and aggregate quality control testing using an approved, independent commercial testing laboratory. Submit test results to the Contracting Officer.

1.5 DELIVERY AND STORAGE

Lift and support precast members at the lifting and supporting points indicated on the shop drawings. Store precast members off the ground. Separate stacked precast members by battens across the full width of each bearing point. Protect from weather, marring, damage, and overload.

1.6 FACTORY INSPECTION

At the option of the Contracting Officer, precast units may be inspected by the Contracting Officer prior to being transported to the job site. The Contractor shall give notice 14 days prior to the time the units will be available for plant inspection. Neither the exercise nor waiver of inspection at the plant will affect the Government's right to enforce contractual provisions after units are transported or erected.

1.7 QUALITY ASSURANCE

1.7.1 Drawing Information

Submit drawings indicating complete information for the fabrication, handling, and erection of the precast member. Drawings shall not be reproductions of contract drawings. Design calculations and drawings of precast members (including connections) shall be prepared and sealed by a registered professional engineer, and submitted for approval prior to fabrication. The drawings shall indicate, as a minimum, the following information:

a. Marking of members for erection

b. Connections for work of other trades

c. Connections between members, and connections between members and other construction

d. Location and size of openings

e. Headers for openings

f. Joints between members, and joints between members and other construction

g. Reinforcing details

h. Material properties of steel and concrete used

i. Lifting and erection inserts

j. Dimensions and surface finishes of each member

k. Erection sequence and handling requirements

l. All loads used in design (such as live, dead, handling, and erection)

m. Bracing/shoring required

1.7.2 Design Calculations

Submit calculations reflecting design conforming to requirements of paragraph entitled "Precast Concrete Member Design." Design calculations and drawings of precast members (including connections) shall be prepared and sealed by a registered professional engineer, and submitted for approval prior to fabrication.

1.7.3 Concrete Mix Design

Thirty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Include a complete list of materials including type; brand; source and amount of cement, pozzolan, and admixtures; and applicable reference specifications.

1.7.4 Certificates: Record Requirement

ASTM C 94. Submit mandatory batch ticket information for each load of ready-mixed concrete.

PART 2 PRODUCTS

2.1 CONTRACTOR-FURNISHED MIX DESIGN

ACI 318/318M. The minimum compressive strength of concrete at 28 days shall be 35 MPa,unless otherwise indicated. Add air-entraining admixtures at the mixer to produce between 4 and 6 percent air by volume.

2.2 MATERIALS

2.2.1 Cement

Cement shall be in accordance with Paragraph 2.1 of Section 03300 "Concrete Reinforcement"

2.2.2 Water

Water shall be fresh, clean, and potable.

2.2.3 Aggregates

2.2.3.1 Aggregates Selection

ASTM C 33. Obtain aggregates for exposed concrete surfaces from one source. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalies in the cement.

2.2.4 Grout

2.2.4.1 Nonshrink Grout

ASTM C 1107.

2.2.4.2 Cementitious Grout

Shall be a mixture of portland cement, sand, and water. Proportion one part cement to approximately 2.5 parts sand, with the amount of water based on placement method.

2.2.5 Admixtures

2.2.5.1 Air-Entraining

ASTM C 260.

2.2.5.2 Accelerating

ASTM C 494, Type C or E.

2.2.5.3 Water Reducing

ASTM C 494, Type A, E, or F.

2.2.6 Reinforcement

2.2.6.1 Reinforcing Bars

Reinforcing steel shall be deformed bars conforming to ASTM A 615/A 615M, epoxy-coated in accordance with ASTM A 934/A 934M and ASTM A 706/A 706M for welded reinforcing steel, zinc-coated in accordance to ASTM A 767/A 767M, grades and sizes as indicated.

2.2.6.2 Welded Wire Fabric

ASTM A 884/A 884M.

2.2.7 Metal Accessories

Provide ASTM A 123/A 123M or ASTM A 153/A 153M galvanized.

2.2.7.1 Inserts

ASTM A 47M, Grade 22010, or ASTM A 27/A 27M Grade 415-205.

2.2.7.2 Structural Steel

ASTM A 36/A 36M.

2.2.7.3 Bolts

ASTM A 307.

2.2.7.4 Nuts

ASTM A 563M.

2.2.7.5 Washers

ASTM F 844 washers for ASTM A 307 bolts.

2.2.8 Bearing Pads

2.2.8.1 Elastomeric

AASHTO SSHB-I-14, for plain neoprene bearings.

2.2.8.2 Hardboard (Interior Only)

ANSI A135.4, class as specified by the precast manufacturer.

2.3 FABRICATION

PCI MNL-116 unless specified otherwise.

2.3.1 Forms

Brace forms to prevent deformation. Forms shall produce a smooth, dense surface. Chamfer exposed edges of columns and beams 200 mm, unless otherwise indicated. Provide threaded or snap-off type form ties.

2.3.2 Reinforcement Placement

ACI 318/318M for placement and splicing. Reinforcement may be preassembled before placement in forms. Provide exposed connecting bars, or other approved connection methods, between precast and cast-in-place construction. Remove any excess mortar that adheres to the exposed connections.

2.3.3 Concrete

2.3.3.1 Concrete Mixing

ASTM C 94. Mixing operations shall produce batch-to-batch uniformity of strength, consistency, and appearance.

2.3.3.2 Concrete Placing

ACI 304R, ACI 305R for hot weather concreting and ACI 309R, unless otherwise specified.

2.3.3.3 Concrete Curing

Commence curing immediately following the initial set and completion of surface finishing. Provide curing procedures to keep the temperature of the concrete between 10 and 90 degrees C. When accelerated curing is used, apply heat at controlled rate and uniformly along the casting beds. Monitor temperatures at various points in a product line in different casts.

2.3.4 Surface Finish

Repairs located in a bearing area shall be approved by the Contracting Officer prior to repairs. Precast members containing hairline cracks which are visible and are less than 0.5 mm in width, may be accepted, except that cracks larger than 0.1 mm in width for surfaces exposed to the weather shall be repaired. Precast members which contain cracks greater than 0.5 mm in width shall be approved by the Contracting Officer, prior to being repaired. Any precast member that is structurally impaired or contains honeycombed section deep enough to expose reinforcing shall be rejected.

2.3.4.1 Unformed Surfaces

Provide a floated finish.

2.3.4.2 Formed Surfaces

PCI MNL-116 (Appendix A - Commentary), Chapter 3, for grades of surface finishes.

a. Unexposed Surfaces: Provide a commercial grade surface finish.

b. Exposed Surfaces: Provide a standard grade surface finish. The combined area of acceptable defective areas shall not exceed 0.2 percent of the exposed to view surface area, and the patches shall be indistinguishable from the surrounding surfaces when dry.

PART 3 EXECUTION

3.1 SURFACE REPAIR

Prior to erection, and again after installation, precast members shall be checked for damage, such as cracking, spalling, and honeycombing. As directed by the Contracting Officer, precast members that do not meet the surface finish requirements specified in Part 2 in paragraph entitled "Surface Finish" shall be repaired, or removed and replaced with new precast members.

3.2 ERECTION

Precast members shall be erected after the concrete has attained the specified compressive strength, unless otherwise approved by the precast manufacturer. Erect in accordance with the approved shop drawings. PCI MNL-116 and PCI MNL-120 (Chapter 8), for tolerances. Brace precast members, unless design calculations submitted with the shop drawings indicate bracing is not required. Follow the manufacturer's recommendations for maximum construction loads. Place precast members level, plumb, square, and true within tolerances. Align member ends.

3.3 BEARING SURFACES

Shall be flat, free of irregularities, and properly sized. Size bearing surfaces to provide for the indicated clearances between the precast member and adjacent precast members or adjoining field placed surfaces. Correct bearing surface irregularities with nonshrink grout. Provide bearing pads where indicated or required. Do not use hardboard bearing pads in exterior locations. Place precast members at right angles to the bearing surface, unless indicated otherwise, and draw-up tight without forcing or distortion, with sides plumb.

3.4 ANCHORAGE

Provide anchorage for fastening work in place. Conceal fasteners where practicable. Make threaded connections up tight and nick threads to prevent loosening.

3.5 WELDING

AWS D1.4 for welding connections and reinforcing splices. Protect the concrete and other reinforcing from heat during welding. Weld continuously along the entire area of contact. Grind smooth visible welds in the finished installation. Welding of epoxy-coated reinforcing is not allowed.

3.6 OPENINGS

Holes or cuts requiring reinforcing to be cut, which are not indicated on the approved shop drawing, shall only be made with the approval of the Contracting Officer and the precast manufacturer. Drill holes less than300 mm in diameter with a diamond tipped core drill.

3.7 GALVANIZING REPAIR

Repair damage to galvanized coatings using ASTM A 780 zinc rich paint for galvanized surfaces damaged by handling, transporting, cutting, welding, bolting, or acid washing. Do not heat surfaces to which repair paint has been applied.

3.8 GROUTING

Clean and fill keyways between precast members, and other indicated areas, solidly with nonshrink grout or cementitious grout. Provide reinforcing where indicated. Remove excess grout before hardening.

3.9 SEALANTS

Provide as indicated and as specified in Section 07900, "Joint Sealing."

-- End of Section --

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DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13038

COLD-STORAGE ROOMS (PREFABRICATED PANEL TYPE)

-- End of Section Table of Contents --

SECTION 13038

COLD-STORAGE ROOMS (PREFABRICATED PANEL TYPE)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 580/A 580M	(1994) Stainless and Heat-Resistant Steel Wire
ASTM E 580	(1991) Application of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Requiring Seismic Restraint

MILITARY SPECIFICATIONS (MS)

MIL-R-43900	(Rev. B) Refrigerators, Freezers, Prefabricated, Mechanical, Commercial, Walk-In

NSF INTERNATIONAL (NSF)

NSF 7	(1997) Commercial Refrigerators and Storage Freezers

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES: Submit the following in accordance with Section 01330, "Submittal Procedures."

SD-02 Shop Drawings

Cold storage rooms

Submit shop drawings for cold storage rooms, indicating wall and ceiling panels, refrigerated doors, pallet storage racks, refrigeration equipment, fire protection systems, electrical lighting, and other associated construction.

SD-03 Product Data

Cold storage rooms

Submit manufacturer's catalog data for cold storage rooms.

SD-08 Manufacturer's Instructions

Cold storage rooms

Submit manufacturer's installation instructions for cold storage rooms.

SD-10 Operation and Maintenance Data

Cold storage rooms, **G, ED**

Submit operation and maintenance data for cold storage rooms.

PART 2 PRODUCTS

2.1 COLD STORAGE ROOMS

The cold storage room shall conform to NSF 7 and to MIL-R-43900, factory-fabricated type, and modified as required with the following requirements:

a. Type I - Chill Rooms, and Type II - Freezer.

b. Style A, floorless design.

c. Insulated Wall and Ceiling Panels: Wall panels shall be not less than 7 010 mm high for chilled and freezer rooms, and not less than 4 200 mm for the ice storage room and issue/receive area. Modular prefabricated insulated wall and ceiling panels shall be designed for accurate and easy field erection. Panels shall be inset ribbed panels exactly formed with metal dies to ensure panel uniformity and assure interchangeability with like panels. Metal panels shall have an inside preparation coat of bonding agent to create a stable adhesion with the foam insulation. Panels shall be made without internal wood or metal structural members, with 100% of each panel exclusive of metal pans and locking devices being of foam polyurethane insulation. Panel edges shall be tongue and groove configuration lap design or other configurations to assure proper alignment and airtight, vaporproof joints. **In addition to the standard live loads, design ceiling panels to withstand loads, not less than 120 kilograms, derived from maintenance personnel walking on top of ceiling panels to service equipment and piping.**

d. Wall and Ceiling Fastening System: All modular panel sections shall be locked securely together with cam-lock fasteners for tongue and groove configuration or with self tapping screws for lap design configuration. Cam-locking fasteners shall consist of a cam action, positioned in the groove section. Locking arm and metal rod shall be contained within metal housing. By the rotation of the locking arm, the hook shall engage over the rod and draw the panel section tightly together. Locking arm shall be by means of a standard hexagonal wrench. Pres-fit caps shall be provided to close wrench holes. There shall be not less than three cam-lock fasteners in each vertical and horizontal joint. Horizontal placement of cam-locks at wall/ceiling or wall/floor juncture shall not exceed 600 mm. Spacing of self tapping screws for lap design configuration panels shall be in accordance with manufacturer' s printed instructions.

e. Fasteners: Fasteners for attachment to structural supports and fasteners for attachment to adjoining panels shall be as approved, and in accordance with the manufacturer's recommendation. Unless specified otherwise herein, the fasteners shall be bolts and nuts, No 14 self tapping screws, and/or expansion type fasteners. Fasteners shall be stainless steel, except, for expansion type fasteners, which shall be stainless steel and aluminum. All fasteners shall have composite metal and polychloroprene washers.

f. Outside Insulated Panel Supports: Provide structural support system outside of the refrigerated space. The support system shall be designed and as recommended by the insulated panel system manufacturer. Suspension systems for insulated ceiling panels shall be fabricated from aluminum with clear anodized finish or Type 316 stainless steel, designed, sized to meet load requirements, and meet seismic requirements conforming to ASTM E 580. Epoxy filled anchors with self-contained epoxy or polyester resin capsule shall be threaded stainless steel anchor rod. Hanger wires, if required, shall be stainless steel conforming to ASTM A 580/A 580M, not less than (10-1/2 gage) 3 mm diameter. Hanger rods, if required, shall be not less than (3/8") 9 mm diameter Type 316 stainless steel. All fasteners and anchors shall be Type 316 stainless steel.

g. Swinging doors shall be single and double swing types with right-handed and left-handed openings as indicated. Sliding doors shall be electric operated, bi-parting, and manual operated, single slide. Sizes and heights of door openingss shall be as indicated. Doors and frames shall be stainless steel construction, except where ABS constructed doors are indicated.

h. Electrical characteristics as indicated.

i. Preservation and packing shall be Level A, overseas shipment.

j. Provide recording thermometer.

k. Provide temperature alarm system with connector for remote temperature alarm.

l. Provide interior lighting.

2.2 PALLET STORAGE RACKS

Pallet storage racks shall be specified in section 11551 PALLET STORAGE RACKS.

2.3 REFRIGERATION EQUIPMENT

Refrigeration equipment shall be as indicated and as specified in Section 15652 COLDSTORAGE REFRIGERATION SYSTEMS.

2.4 HYDRONIC FLOOR WARMING SYSTEM

Hydronic floor warming system below freezer floors shall be as indicated and as specified in Section 13040 HYDRONIC FLOOR WARMING SYSTEM.

2.5 WET PIPE SPRINKLER SYSTEM

Wet pipe sprinkler system shall be as indicated and as specified in Section 13930 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION.

2.6 FIRE ALARM DEVICES

Provide special fastening system for the fire alarm devices as specified in Section 13851 FIRE DETECTION AND ALARM SYSTEM, ADDRESSABLE.

PART 3 EXECUTION

3.1 INSTALLATION

Installation procedures shall conform to NSF 7, and the manufacturer's instructions. Submit a set of instructions covering both assembly of the rooms and installation of the refrigeration equipment before starting installation.

3.1.1 Epoxy Filled Anchor Installation

Install epoxy filled anchors at precast prestressed concrete tees in accordance with the manufacturer's printed instructions. The anchor studs shall be clean of dirt, dust, paint, grease, oil, rust, or other contamination or other coating which would prevent direct coating adhesion. Drill proper sized holes. Clean out hole with wire brush and blowout-bulb or blowout hose attached to the injector tool. Prior to injection, discharge approximately one fluid ounce of epoxy; the epoxy color shall match the color band on the nozzle valve nut. Insert the nozzle into the bottom of the hole and fill the hole to 1/2 the hole depth. Insert the selected rod slowly by hand into the bottom of the hole using a slow twisting motion to ensure the epoxy fills the voids and crevices. Hardening will begin in approximately 7 minutes at room temperature. Install and tighten steel members after 24 hours of curing.

3.2 MANUFACTURER'S FIELD SERVICES

Furnish manufacturer's representatives who are trained to perform the services specified. The representatives shall furnish and services on the following matters:

a. Erection, alignment, and testing.

b. Charging equipment with refrigerant and oil.

c. Starting equipment and training government personnel as to its proper care, operation, and maintenance.

3.3 TESTS

Perform the tests for each room and provide everything required. Notify the Contracting Officer 10 days before performing the tests. Tests shall be performed in the presence of a manufacturer's representative.

3.3.1 Start-Up and Operational Tests

Start up and initially operate the systems upon completion of the installation of the equipment and refrigerant piping. Adjust the safety and automatic controls to place them in operation and sequence. Record

manufacturer's recommended readings hourly. Operational tests shall cover a period of not less than 24 hours.

3.3.2 Performance Tests

Upon completion of the operational tests the systems shall be performance tested. Test duration shall not be less than 8 hours. Tests shall include the following information to be in the report with conclusions regarding the adequacy of the systems:

a. Time, dates and duration of tests.

b. Inside dry-bulb and wet-bulb temperatures maintained in each room during the tests employing recording instruments calibrated before the tests.

c. Outside dry-bulb and wet-bulb temperatures obtained from recording instruments calibrated and checked hourly with a sling psychrometer.

d. Evaporator and condenser entering and leaving temperatures taken hourly with the compressors in operation.

e. The make, model and capacity of each evaporator and condensing unit.

f. Voltmeter and ammeter readings for condensing units and evaporators.

3.4 OPERATING INSTRUCTIONS

Provide a framed and glassed control chart indicating a layout of the refrigeration systems, including piping, valves, wiring, and control mechanisms. Install control chart where directed. Submit printed instructions covering the maintenance and operation of refrigeration equipment. Tag shutoff valves in accordance with the printed instructions. Provide special tools as necessary for repair and maintenance of the equipment.

3.5 CLEANING

Remove masking-protection from stainless steel and other finished surfaces. Wash and clean floors, walls, shelves, and ceilings inside rooms and exposed surfaces on the outside. Clean glass, fixtures and fittings.

3.6 INSTRUCTING OPERATING PERSONNEL

Upon completion of the work and at a time designated by the Contracting Officer, provide for the instruction of Government personnel in the operation and maintenance of each refrigeration system. The period of instruction shall be for not less than one 8-hour working day.

-- End of Section --

SECTION TABLE OF CONTENTS

DIVISION 13 - SPECIAL CONSTRUCTION

SECTION 13040

HYDRONIC FLOOR WARMING SYSTEM

-- End of Section Table of Contents --

SECTION 13040

HYDRONIC FLOOR WARMING SYSTEM

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 300	1985 (Rev. 1987) Reverberant Room Method for Sound Testing of Fans

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A53	1989a Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
ASTM A234	1989a Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

1.2 DESCRIPTION

Provide and underfloor hydronic floor warming system installed in the freezer and ice storage concrete base slab to prevent freeze buildup and floor heavage.

1.3 SCOPE

a. The Contractor shall supply all labor, supervision, tools, equipment and materials for the complete installation and testing of the floor warming system.

b. The Scope of the work shall include, but not be limited to, the furnishing and installation of the following:

(1) Plastic pipe grids for concrete grout base slab under freezer storage.

(2) Testing as hereinafter specified.

(3) All above-floor exposed piping for the floor warming system including flow indicators, vents, valves, strainers, gauges, thermometers and fittings as shown on the Drawing.

(4) Floor warming pumps.

(5) Expansion tank.

(6) All equipment and pipe supports.

(7) 40% ethylene glycol/60% water fluid charge.

(8) Air handler.

(9) Hydronic electric heater.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Hydronic Floor Warming System

Detail drawings consisting of illustrations, schedules, performance charts, instructions, brochures, diagrams, and other information to illustrate the requirements and operations of each system. Detail drawings for the complete system including air moving devices, pumps and associated appurtenances; piping layouts and locations of connections; dimensions for roughing-in, foundation, and support points; and schematic diagrams and wiring diagrams or connection interconnection diagrams; and installation details. Details drawings shall show proposed layout and anchorage of equipment and appurtenances and relationship of equipment to other parts of the work, including clearances required for maintenance and operation.

SD-03 Product Data

Spare Parts

1.4.1 Spare Parts

A complete list in triplicate of parts and supplier with a source of supply, after approval of material and equipment and not later than 2 months prior to the date of beneficial occupancy.

SD-06 Test Reports

Test Reports

1.4.2 Test Reports

Test reports in booklet form showing all field tests performed by the testing laboratory to adjust each component, and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls.

SD-08 Manufacturer's Instructions

Hydronic Floor Warming System

Proposed diagrams, instructions, and other sheets, prior to posting.

Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted where directed. Condensed operating instructions explaining preventative maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system, shall be prepared tin typed form, framed as specified above for the wiring and control diagrams, and posted beside the diagrams. The framed instructions shall be posted before acceptance testing of the systems.

SD-10 Operation and Maintenance Data

Hydronic Floor Warming System, **G, ED**

Six complete copies of operation manuals outlining the step-by-step procedures required for system startup, operation and shutdown. The instructions shall include the manufacturer's name, model number, service manual, and a brief description of all equipment and their basic operating features. Six complete copies of maintenance manuals listing routine maintenance procedures, possible breakdowns and repairs, and trouble shooting guides. The instructions shall include simplified wiring and control diagrams for the system as installed.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a a manufacturer regularly engaged in the manufacturing of such product,s which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 years use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 year experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. system components shall be environmentally suitable for the indicated locations.

2.2 CENTRAL STATION AIR HANDLING UNITS

2.2.1 Factory-Fabricated Air Handling Units

Air handling units shall be energy efficient, factory fabricated, raw-through, central-station type. Unit shall be tested and rated in accordance with ARI 430. Units shall include fans, coils, airtight insulated casing, adjustable V-belt drives, belt guards, access sections where indicated, vibration-isolators, and appurtenances, required for specified operation. Vibration isolators shall be combination rubber-in-shear/spring type for units designated for low and medium pressure duty. Each air handling unit shall have physical dimensions suitable to fit space allotted to the unit and shall have the capacity indicated.

2.2.1.1 Casings

Casing shall be constructed of not lighter than 18-gauge steel protected with the manufacturer's standard finish, except that units with an all welded structural steel frame shall have individually remove\able flush mounted panels or full height access doors not lighter than 20-gauge steel or 20-gauge galvanized steel. Each casing section shall be acoustically and thermally insulated at the factory with not less than 1-inch thick, 1-1/2 pound density coated fibrous glass material having a "u" factor no grater than 0.27. Foam-type insulation with foil backing may be used provided that the insulation meets the thermal, erosion, and fire-resistance requirements, specified for fibrous glass material. Access doors or removable panels where required for servicing shall be provided in the fan-coil section.

2.2.1.2 Coils

Coils shall be water type and shall conform to requirements of paragraph HEATING COILS.

2.2.1.3 Fans

Fans shall be double-inlet, centrifugal type with each fan in a separate scroll. Fans shall be statically and dynamically balanced at the factory after assembly in the air handling unit. Fans shall be mounted on steel shafts accurately ground and finished. Fan bearings shall be sealed against dust and dirt and shall be precision self-aligning ball or roller type with bearing life rated at not less than 200,000 hours as defined by AFBMA 9 and AFBMA 11. Bearings shall be permanently lubricated or lubricated type with lubrication fittings externally accessible at the drive side of the unit. Bearing shall be supported by structural shapes, or die formed sheet structural members, or support plated securely attached to the unit casing. Bearing may not be fastened directly to the unit sheet metal casing. Fans and scrolls shall be furnished with coating indicated. Fans shall be driven by a unit-mounted motor connected to fans by V-belt drive complete with belt guard for motors mounted externally. Belt guards shall be the three-sided enclosed type with solid or expanded metal face. Belt drives shall be designed for not less than 1.4 service factor. Motor sheaves shall be variable pitch for 154 hp and below and fixed pitch above 15 as defined by ARI 430 and ARI Guideline D. Variable pitch sheaves shall be elected to drive the fan at such speed as to produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable bases. Fan motors shall have dripproof enclosures. Motor starters shall be magnetic across-the-line type with general-purpose enclosure. Unit fan or fans shall be selected to produce the required capacity at the fan total pressure. Sound power level, dB reference to 10 to the minus twelfth-power watt, mid-frequency, shall not exceed the value or values for the octave band or bands shown for the unit fan or fans. Fan performance curve for the unit fan or fans shall be submitted at the time the proposed testing program is submitted. Sound power level data in all octave bands for the furnished fan or fans shall be submitted. The sound power level values shall be obtained in accordance with AMCA 300 or ASHRAE 68.

2.2.1.4 Vibration Isolation

Where fan and related motor and power transmission components are located within or mounted on the external surfaces of the cabinet, the entire cabinet shall be vibration isolated from supported and contiguous surfaces;

or the fan and related motor and power transmission components shall be mounted on a common vibration isolation base within the cabinet with factory installed flexible fan connectors. Vibration isolation mountings shall be spring type selected to limit transmissibility of imbalanced forces at lowest equipment rpm to 5 percent.

2.3 HEATING COILS

Coils shall be fin-and-tube type constructed of seamless aluminum or copper tubes of minimum thickness equal to 0.020-inch and aluminum or copper fins of minimum thickness equal to 0.0075-inch, mechanically bonded or soldered to tubes, unless specifically indicated otherwise. Plate type fin-and-tube coils shall be 0.017-inch minimum tube thickness and 0.0055-inch minimum fin thickness. Casing and tube support sheets shall be not lighter than 16-gauge galvanized steel, formed to provide structural strength. When required, multiple tube support sheets shall be not lighter than 16-gauge galvanized steel, formed to provide structural strength. When required, multiple tube supports shall be provided to prevent tube sag. Each coil shall be tested at the factory under water at no less than 250 psi air pressure and shall be suitable for 200 psi working pressure. Coils shall be mounted for counterflow service. Coils shall conform to the provisions of ARI 410.

2.3.1 Water Coils

Water coils shall be circuited for a suitable water velocity without excessive pressure drop and drainable where required or indicated. Where required by the manufacturer, drainable coils shall be installed with a pitch of not less than 1/8-inch per foot of the tube length towards the drain end. Each coil shall be provided with a plugged vent and drain tappings.

2.4 ELECTRIC HYDRONIC WATER HEATER

As specified in section 15400-plumbing, general purpose

2.5 FLOOR WARMING PUMPS

Glycol floor warming pump shall circulate 40% solution by volume of inhibited ethylene glycol at 50 degrees Fahrenheit (average) through the floor grid piping. Pump shall be positive displacement rotary gear type with Teflon-fitted mechanical seals, complete with base, built-in relief valve, starter and motor mounted on a common base.

2.6 EXPANSION TANK

Horizontal expansion tank shall be furnished and installed complete with sight glass connections and supports as shown. Expansion tank shall be 150 psig ASME pressure rated minimum design.

2.7 MIXING TANK

Mixing tank shall be 55 gallon, open top, vertical high density polyethylene mixing tank with bottom outlet and loose cover.

2.8 FLOW INDICATORS

Provide a 1" NPT grid as shown, visual flow indicator/circuit balancer with a stainless steel flow indicating mechanism, integral nonferrous flow

balancing device and cast iron body installed in the return of each grid as shown. The flow indictor/balancing device shall be designed for 125 psig working pressure at a maximum fluid temperature of 250 degrees F, and is designed for replacement of the indicating mechanism without breaking piping connections. Flow indictor shall have a range of 2 to 10 GPM with 1" screw connection.

2.9 PIPE INSULATION

a. All aboveground exposed piping , pumps, and the expansion tank shall be insulated in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

b. All buried hydronic supply and return piping to and from the underfloor tubing grid shall be preinsulated pipe as specified herein.

2.10 STRAINER

Cleanable, 125# cast iron, screwed, Y-type with stainless steel strainer screen having a particle retention size of .030 or smaller shall be furnished and installed in the suction pump.

2.11 PLASTIC PIPE GRIDS

a. Plastic pipe grids shall be polyethylene plastic pipe, polyethylene tubing specifically designed for use in hydronic underfloor heating system. Plastic pipe shall be 1" nominal diameter with a minimum pressure rating of 100 psi at 73 degrees Fahrenheit. Pipe shall be factory tested under water pressure to meet Factory Hydronic Test Specifications. Pipe shall be suitable for direct burial in concrete slab.

b. Plastic insert to MPT nylon adapters shall be secured with two stainless steel worm screw type clamps.

2.12 PIPE

2.12.1 Above-floor glycol piping

Above-floor glycol pipings hall be black, uncoated, standard weight, schedule 40 ASTM A53 steel pipe.

2.12.2 Preinsulated Underground

All underground hydronic lines shall be factory preinsulated with PVC carrier pipe. The pipe shall be insulated with polyurethane foam and enclosed in an outer jacket of PVC. All sections shall be factory prefabricated in 20 foot or 30 foot random length, with end seals provided on both ends of each piece. Factory trained field technical assistance shall be provided for the critical periods of installation; i.e, unloading, field joint instructions, and testing.

2.12.3 Insulation

Carrier pipe insulation shall be one inch thick spray applied or poured in place polyurethane foam with the following minimum properties: two (2) pounds per cubic foot density, 90-95% closed cell content, initial thermal conductivity K = .13. The foam shall completely fill the space between the

carrier pipe and jacket.

2.12.4 Protective Jacket

The protective jacket shall be seamless Polyvinyl Chloride (PVC), Type 1, Grade 1 conforming to ASTM D-1784

The minimum thickness for PVC jacket shall be as follows: for jacket diameter up to 5 inches - thickness = .060 inches; for 6 inch jacket diameter - thickness = .070 inches; for jacket diameter greater than 6 inch - thickness = 1% of diameter.

2.13 FITTINGS

All fittings 1-1/2" and less shall be 150# malleable iron screwed fittings. All fittings 2" and larger shall be butt welded ASTM A234.

2.14 VALVES

All valves except fill, vent, and drain shall be 150# bronze ball valves with TFE seats and seals.

2.15 VENT, FILL AND DRAIN VALVES

Valves for venting air, filling and draining the system shall be 125# globe or angle type with all bronze and/or brass construction.

2.16 THERMOMETERS

Thermometers with separable wells shall be furnished and installed where indicated. Thermometers shall be 3" dial type thermometers with range from 20 degrees Fahrenheit to 120 degrees Fahrenheit.

2.17 PRESSURE GAUGE

4-1/2 inch. 0 to 20 lb. Gauge with shut-off valve shall be furnished and installed where indicated.

2.18 PAINTING

All pipe hangers, anchors, guides, and supports shall be painted in accordance with Section 09900 PAINTING.

2.19 FLUID CHARGE

a. The system shall be fully charged by the Contractor with an inhibited ethylene glycol solution.

b. Glycol for the floor warming system shall be a solution of 40% inhibited glycol and 60% water by volume. Glycol shall have a specific gravity of 1.068 at 50% degrees Fahrenheit. Solution shall be standard manufacturer's premixed solution with antifoaming additive specifically designed hydronic heating systems.

c. The system shall be charged until the expansion tank is one-half full with air vented out of the system and fluid at 55 degrees Fahrenheit, and with the operating system pressure with dry nitrogen to 20 psig pump suction pressure.

d. Provide two 55 gallon drums of 40% ethylene glycol solution for recharging of the system.

PART 3 EXECUTION

3.1 HYDRONIC FLOOR WARMING PIPING INSTALLATION

3.1.1 General

a. Floor warming grids in the base slab of the freezer storage shall be formed with plastic piping. Each grid shall be continuous with NO joints underneath the floor. The ends of each grid shall terminate just outside the freezer with a nylon, plastic inert to MPT adapter. All above-floor piping from the grids to the floor warming pump and heat and heat exchanger shall be steel piping.

b. Each of the grids shall be a continuous length of pipe with absolutely no joints buried in the concrete grout or underground. Contractor may purchase special continuous lengths to suit the grid layout; providing delivery of special lengths will not delay job installation. Otherwise, Contractor shall install each individual grid from a stock continuous length of pipe.

3.1.2 Installation

a. Special care shall be taken so that pipe is not damaged in any way during installation and pouring of concrete grout. Pipe shall be filled with water and MAINTAINED UNDER 60 PSIG PRESSURE at time of pouring grout.

b. Piping shall be formed, located and laid directly on the backfill surface as shown. Where changes of direction occur, pipe shall be loosely staked in position on the backfill using "U" shaped #10 wire anchors. Pipe does not have to be perfectly straight, 3" to 4" snaking will be acceptable. Anchors shall be positioned on straight runs at a maximum spacing of 20 feet to maintain grid pattern shown.

c. Both ends of each loop shall terminate with a 1" male nylon adapter outside the freezer.

d. Install a ½" thick unicellular insulation sleeve on each pipe where it penetrates the foundation wall.

e. Provide notches in the foundation wall for penetrations where required.

3.1.3 Pipe Grid Testing

3.1.3.1 General

a. Each plastic pipe grid shall be tested as described below before being embedded in the concrete grout.

b. The Contractor shall use extreme care in checking all grid piping, so as to positively prove that no leaks exist when

c. the concrete grout is poured. Absolutely no evidence of leakage will be permitted.

d. It is suggested that the grids be temporarily headered together for the testing period.

e. Before testing, each circuit shall be blown out with dry air to demonstrate that the grid is not obstructed.

f. Before the concrete grout is poured, each circuit that is to be buried in concrete grout shall receive two separate tests for tightness.

g. The Contractor shall keep a careful check on the pressure during the hydraulic test to maintain the test pressure. A means shall be provided to vent the system if the pressure rises above test pressure due to the expansion of the water if cold water is used to fill the system in warm weather.

h. If the ambient temperature is below freezing at the time of the hydostatic test, a glycol antifreeze solution shall be used for the test. The hydrostatic test shall be delayed if the outside surface of the pipe or the surface that the pipe is resting on is wet or if conditions restrict the detection of leaks in any way.

i. At the conclusion of the tests, all water shall be blown out with dry air. Special care must be exercised to ensure that the pipe grid is completely free of water and moisture to prevent freeze-up during winter construction months. Also, any remaining moisture will dilute the glycol solution when it is charged into the system.

3.1.3.2 Plastic Pipe Grids

a. Test #1 for the plastic pipe grids shall consist of air test at 90 psig. Pressure shall be applied and maintained for a minimum of 30 minutes.

b. Test #2 for the plastic pipe grids shall consist of a hydrostatic test at 60 psig. Each grid shall be completely filled with water and all air vented out of the system. Hydrostatic pressure shall be maintained for a minimum of two hours. During the test every foot of the grid system shall be inspected for leakage.

c. As a final double check, water pressure at 60 psig shall be applied as the concrete grout is being poured and maintained for a period of not less than twelve hours after completion of the pour.

d. If any leakage is detected visually or any abnormal drops in test pressure are detected at any time during tests #1 and #2 or during the co9ncrete grout pour, or after the concrete grout has been poured, the pipe grid will be removed and replace and the entire test procedure shall be repeated.

e. The pipe will not be accepted until tests #1 and #2 have been strictly complied with in the presence of the Contracting Officer.

3.1.4 Above-Floor Glycol Piping

3.1.4.1 General

a. Above-floor piping includes supply and return pipe headers from all pipe grids to the floor warming pumps and all interconnecting piping to the air handler, electric heater, and expansion tank.

b. No piping shall be run concealed in walls or partitions, not underground or under the floor, except as shown.

3.1.4.2 Joints

a. All screwed joints in steel pipe shall be tape wrapped.

b. All welded joints shall be made by certified welders with the inside of the pipe relatively free of welding slag, scale and drippings.

3.1.4.3 Pipe Hangers and Supports

a. All pipe hangers, equipment supports, anchors, guides, and supports shall be provided and installed by the Contactor.

b. Chain, perforated and flat steel strip hangers will not be acceptable.

c. Care shall be taken to insure that bracing and supports will not restrain expansion and contraction nor set up excessive stresses at joints and at equipment.

d. All hangers supplied for insulated lines shall be sized for the outside diameter of the applied insulation. The Contractor shall provide temporary wooden blocks, properly sized for insulation thickness, which will accurately center the pipe in the hanger and enable the insulation to be applied without disturbing hanger settings.

e. All hangers, anchors, guides, and supports shall be protected from corrosion by painting as specified.

3.1.4.4 Pipe Insulation

All above-floor piping shall be insulated in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.4.5 Tests

The above-floor piping system shall be pressure tested at a pressure at least 50% above normal working pressure. Leaks shall be repaired by removing and remaking the defective joint. No caulking will be permitted. After repair of leaks, system shall be retested and proved tight.

3.1.5 Underground Glycol Piping

3.1.5.1 Casing and End Seal Testing and Certification

Testing, verified by an independent testing laboratory, shall demonstrate that casings and end seals are capable of resisting penetration of water into the casing and insulation at 20 feet of head pressure, measured above

the highest point of the test sample, subjected over entire surface of the 8 feet long test sample on FRP pipe for not less than 48 hours after the sample has been subjected to hot and cold cycle testing. The hot and cold cycle testing shall consist of 14 days of cycling with 24 periods with fluid at ambient temperature following through the carrier pipe alternately with 24 hour period with 300 degrees Fahrenheit fluid flowing through the carrier pipe while the sample is buried in a minimum of 12 inches of sand all around the sample.

3.1.5.2 Backfill

A 4 inch layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 to 12 inches above the top of the insulated piping system. The remaining trench shall be evenly continuously backfilled in uniform layers with suitable excavated soil.

3.2 CUTTING AND PATCHING

The General Contractor will notch the walls for the floor warming pipes. The Contractor shall give location dimensions to the General Contractor. If location is not given prior to erection of the wall, all required cutting and patching in the masonry wall be at the expense of the Floor Warming Contractor.

3.3 SYSTEM BALANCING

a. The flow to each circuit shall be adjusted by the pipe grid balancing valve. The relative amount to each circuit can be approximated by noting the indicated height of the flow indicators. The amount of flow through each circuit shall be adjusted so that it gives and equal temperature range across all circuits.

b. The glycol heat exchanger refrigerant pressure regulating valve shall be adjusted to maintain the temperature of the glycol solution to the grids at 50 degrees Fahrenheit.

3.4 CONTROLS

All controls for the hydronic underfloor heating system shall be as specified in Section 15652, "Cold Storage Refrigeration Systems".

3.5 START UP

Contractor shall start up the system, adjust for equal flow to all grids, vent all air and clean all strainers.

3.6 FULL STRENGTH GYLCOL VERIFICATION

After the system has been filled with a proper charge of fluid, all grids balanced for proper flow, and the system has been in proper working operation for at least 24 hours, a sample of the glycol solution shall be taken from the system and tested for strength. The strength of the fluid shall have a freezing point of no higher than -15 degrees Fahrenheit.

3.7 SYSTEM COMMISSIONING

System commissioning shall be in accordance with Section 15995 Commissioning of Mechanical Systems

-- End of Section --

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DIVISION 15 - MECHANICAL

SECTION 15070

SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT

-- End of Section Table of Contents --

SECTION 15070

SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ENGINEERING TECHNICAL INSTRUCTIONS (TI) AND ENERGY SAVINGS ANALYSIS (ESA)

TI 809-04	(1998) Seismic Design for Buildings

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA Seismic Restraint Mnl	(1998) Seismic Restraint Manual Guidelines for Mechanical Systems

1.2 SYSTEM DESCRIPTION

1.2.1 General Requirements

The requirements for seismic protection measures described in this section shall be applied to the mechanical equipment and systems listed below. Structural requirements shall be in accordance with Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

1.2.2 Mechanical Equipment

Mechanical equipment to be seismically protected shall include the following items to the extent required on the drawings or in other sections of these specifications:

Water Heaters
Refrigerant Piping
Pumps with Motors
Water, Piping
Valves and Fittings for Piping
Refrigerant Compressors
Air Handling Units
Ducts
Unit Coolers
Exhaust Fans

1.2.3 Mechanical Systems

The following mechanical systems shall be installed as required on the drawings and other sections of these specifications and shall be seismically protected in accordance with this specification All piping

inside the building except as specifically stated below under items not covered by this section

Sanitary Sewer Systems
Cold Storage Refrigeration Systems

1.2.4 Contractor Designed Bracing

The Contractor shall design the bracing in accordance with TI 809-04 and additional data furnished by the Contracting Officer. Resistance to lateral forces induced by earthquakes shall be accomplished without consideration of friction resulting from gravity loads. TI 809-04 uses parameters for the building, not for the equipment in the building; therefore, corresponding adjustments to the formulas shall be required. Loadings determined using TI 809-04 are based on strength design; therefore, the AISC LRFD Specifications shall be used for the design. The bracing for the following mechanical equipment and systems shall be developed by the Contractor:

Water Heaters
Refrigerant Piping
Pumps and Motors
Water Piping
Valves
Refrigerant Capressors
Air Handling Units
Exhaust Fans
Ductwork
Unit Coolers
Cold Storage Refrigeration Systems

1.2.5 Items Not Covered By This Section

1.2.5.1 Fire Protection Systems

Seismic protection of piping for fire protection systems shall be installed as specified in Sections 13930 WET PIPE SPRINKLER SYSTEM, FIRE PROTECTION.

1.2.5.2 Items Requiring No Seismic Restraints

Seismic restraints are not required for the following items:

a. Piping in boiler and mechanical equipment rooms less than 32 mm inside diameter.

b. All other piping less than 64 mm inside diameter.

c. Rectangular air handling ducts less than 0.56 square meters in cross sectional area.

d. Round air handling ducts less than 711 mm in diameter.

e. Piping suspended by individual hangers 300 mm or less in length from the top of pipe to the bottom of the supporting structural member where the hanger is attached, except as noted below.

f. Ducts suspended by hangers 300 mm or less in length from the top of the duct to the bottom of the supporting structural member, except as noted below.

In exemptions e. and f. all hangers shall meet the length requirements. If the length requirement is exceeded by one hanger in the run, the entire run shall be braced. Interior piping and ducts not listed above shall be seismically protected in accordance with the provisions of this specification.

1.3 EQUIPMENT REQUIREMENTS

1.3.1 Rigidly Mounted Equipment

The following specific items of equipment: Equipment to be furnished under this contract shall be constructed and assembled to withstand the seismic forces specified in TI 809-04, Chapter 10. Each item of rigid equipment shall be entirely located and rigidly attached on one side only of a building expansion joint. Piping, duct, electrical conduit, etc., which cross the expansion joint shall be provided with flexible joints that are capable of accommodating displacements equal to the full width of the joint in both orthogonal directions.

Air-Handling Units
Compressor Racks
Air Conditioning Units

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Contractor Designed Bracing, **G, ED**.

Detail drawings along with catalog cuts, templates, and erection and installation details, as appropriate, for the items listed. Submittals shall be complete in detail; shall indicate thickness, type, grade, class of metal, and dimensions; and shall show construction details, reinforcement, anchorage, and installation with relation to the building construction.

SD-03 Product Data

Coupling and Bracing.
Equipment Requirements.

Copies of the design calculations with the detail drawings. Calculations shall be stamped by a registered engineer and shall verify the capability of structural members to which bracing is attached for carrying the load from the brace.

Contractor Designed Bracing; G, RE.

Copies of the design calculations with the drawings. Calculations shall be approved, certified, stamped and signed by a registered Professional Engineer. Calculations shall verify the capability of structural members to which bracing is attached for

carrying the load from the brace.

SD-07 Certificates

Flexible Ball Joints.

Flexible ball joints shall be certified to be suitable for the service intended by the manufacturer. Information verifying experience at not less than 3 locations of 2 years' satisfactory operation in a similar application shall be submitted.

PART 2 PRODUCTS

2.1 FLEXIBLE COUPLINGS

Flexible couplings shall have same pressure and temperature ratings as adjoining pipe.

2.2 FLEXIBLE BALL JOINTS

Flexible ball joints shall have cast or wrought steel casing and ball parts capable of 360-degree rotation with not less than 15-degree angular movement.

2.3 FLEXIBLE MECHANICAL JOINTS

a. Mechanical couplings for steel or cast iron pipe shall be of the sleeve type and shall provide a tight flexible joint under all reasonable conditions, such as pipe movement caused by expansion, contraction, slight settling or shifting of the ground, minor variations in trench gradients, and traffic vibrations. Where permitted in other sections of these specifications, joints utilizing split-half couplings with grooved or shouldered pipe ends may be used.

b. Sleeve-type couplings shall be used for joining plain-end pipe sections. The coupling shall consist of one steel middle ring, two steel followers, two gaskets, and necessary steel bolts and nuts to compress the gaskets.

2.4 MANUFACTURED BALL JOINTS

Manufactured ball joints shall be as recommended by the manufacturer for the intended use, and shall be approved by the Contracting Officer before installation.

2.5 SWAY BRACING MATERIALS

Sway bracing materials (e.g. rods, plates, rope, angles, etc.) shall be as specified in Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT.

PART 3 EXECUTION

3.1 COUPLING AND BRACING

Coupling installation shall conform to the details shown on the drawings. Provisions of this paragraph apply to all piping within a 1.5 m line around outside of building unless buried in the ground. Piping grouped for support on trapeze-type hangers shall be braced at the same intervals as

determined by the smallest diameter pipe of the group. Bracing rigidly attached to pipe flanges, or similar, shall not be used where it would interfere with thermal expansion of piping.

3.2 BUILDING DRIFT

Joints capable of accommodating seismic displacements shall be provided where pipes pass through a building seismic or expansion joint, or where rigidly supported pipes connect to equipment with vibration isolators. Horizontal piping across expansion joints shall accommodate the resultant of the drifts of each building unit in each orthogonal direction. For threaded piping, swing joints made of the same piping material shall be provided. For piping with manufactured ball joints the seismic drift shall be 0.015 meters per meter of height above the base where the seismic separation occurs; this drift value shall be used in place of the expansion given in the manufacturer's selection table.

3.3 FLEXIBLE COUPLINGS OR JOINTS

3.3.1 Building Piping

Flexible couplings or joints in building piping shall be provided at bottom of all pipe risers for pipe larger than 90 mm in diameter. Flexible couplings or joints shall be braced laterally without interfering with the action of the flexible coupling or joint. Cast iron waste and vent piping need only comply with these provisions when caulked joints are used. Flexible bell and spigot pipe joints using rubber gaskets may be used at each branch adjacent to tees and elbows for underground waste piping inside of building to satisfy these requirements.

3.3.2 Underground Piping

Underground piping and 100 mm or larger conduit, except heat distribution system, shall have flexible couplings installed where the piping enters the building. The couplings shall accommodate 76 mm of relative movement between the pipe and the building in any direction. Additional flexible couplings shall be provided where shown on the drawings.

3.4 PIPE SLEEVES

Pipe sleeves in interior non-fire rated walls shall be sized as indicated on the drawings to provide clearances that will permit differential movement of piping without the piping striking the pipe sleeve. Pipe sleeves in fire rated walls shall conform to the requirements in Section 07840 FIRESTOPPING.

3.5 SPREADERS

Spreaders shall be provided between adjacent piping runs to prevent contact during seismic activity whenever pipe or insulated pipe surfaces are less than 100mm apart. Spreaders shall be applied at same interval as sway braces at an equal distance between the sway braces. If rack type hangers are used where the pipes are restrained from contact by mounting to the rack, spreaders are not required for pipes mounted in the rack. Spreaders shall be applied to surface of bare pipe and over insulation on insulated pipes utilizing high-density inserts and pipe protection shields in accordance with the requirements of Section 15080THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.6 SWAY BRACES FOR PIPING

Sway braces shall be provided to prevent movement of the pipes under seismic loading. Braces shall be provided in both the longitudinal and transverse directions, relative to the axis of the pipe. The bracing shall not interfere with thermal expansion requirements for the pipes as described in other sections of these specifications.

3.6.1 Transverse Sway Bracing

Transverse sway bracing for PVC and copper pipe shall be provided as specified in Section 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT. All runs (length of pipe between end joints) shall have a minimum of two transverse braces. Transverse sway bracing for pipes of materials other than steel and copper shall be provided at intervals not to exceed the hanger spacing as specified in Section 15400 PLUMBING, GENERAL PURPOSE.

3.6.2 Longitudinal Sway Bracing

Longitudinal sway bracing shall be provided at 12 m intervals unless otherwise indicated. All runs (length of pipe between end joints) shall have one longitudinal brace minimum. Sway braces shall be constructed in accordance with the drawings. Branch lines, walls, or floors shall not be used as sway braces.

3.6.3 Vertical Runs

Run is defined as length of pipe between end joints. Vertical runs of piping shall be braced at not more than 3 m vertical intervals. Braces for vertical runs shall be above the center of gravity of the segment being braced. All sway braces shall be constructed in accordance with the drawings. Sway branches shall not be connected to branch lines, walls, or floors.

3.6.4 Clamps and Hangers

Clamps or hangers on uninsulated pipes shall be applied directly to pipe. Insulated piping shall have clamps or hangers applied over insulation in accordance with Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.7 SWAY BRACES FOR DUCTS

3.7.1 Braced Ducts

Bracing details and spacing for rectangular and round ducts shall be in accordance with SMACNA Seismic Restraint Mnl, including Appendix E. However, the design seismic loadings for these items shall not be less than loadings obtained using the procedures in TI 809-04.

3.7.2 Unbraced Ducts

Hangers for unbraced ducts shall be attached to the duct within 50 mm of the top of the duct in accordance with SMACNA Seismic Restraint Mnl. Unbraced ducts shall be installed with a 150 mm minimum clearance to vertical ceiling hanger wires.

-- End of Section --

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DIVISION 15 - MECHANICAL

SECTION 15652

COLD STORAGE REFRIGERATION SYSTEMS

-- End of Section Table of Contents --

SECTION 15652

COLD STORAGE REFRIGERATION SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR-CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI 420	(1995) Unit Coolers for Refrigeration
ARI 460	(1994) Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
ARI 495	(1993) Refrigerant Liquid Receivers
ARI 520	(1997) Positive Displacement Condensing Units
ARI 710	(1995) Liquid-Line Driers
ARI 720	(1997) Refrigerant Access Valves and Hose Connectors
ARI 750	(1994) Thermostatic Refrigerant Expansion Valves
ARI 760	(1994) Solenoid Valves for Use With Volatile Refrigerants

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI A13.1	(1996) Scheme for the Identification of Piping Systems

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53	(1998) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 307	(1997) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 653/A 653M	(1997) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus

ASTM B 209	(1996) Aluminum and Aluminum-Alloy Sheet and Plate
ASTM B 221	(1996) Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes
ASTM B 280	(1997) Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM C 534	(1994) Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet & Tubular Form
ASTM D 520	(1984; R 1995) Zinc Dust Pigment
ASTM D 3308	(1997) PTFE Resin Skived Tape
ASTM F 104	(1993) Nonmetallic Gasket Materials

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 15	(1994) Safety Code for Mechanical Refrigeration
ASHRAE 23	(1993) Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B31.1	(1998) Power Piping
ASME B31.5	(1992; B31.5a) Refrigeration Piping
ASME B40.1	(1991) Gauges - Pressure Indicating Dial Type - Elastic Element
ASME BPV VIII Div 1	(1998) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME BPV IX	(1998) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications

AMERICAN WELDING SOCIETY (AWS)

AWS Brazing Hdbk	(1991) Brazing Handbook
AWS A5.8	(1992) Filler Metals for Brazing and Braze Welding

INTERNATIONAL INSTITUTE OF AMMONIA REFRIGERATION (IIAR)

IIAR 2	(1992) Equipment, Design, and Installation of Ammonia Mechanical Refrigerating Systems

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(1996) Pipe Hangers and Supports - Selection and Application

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993) Industrial Control and Systems, Enclosures
NEMA MG 1	(1993; Rev 1; Rev 2; Rev 3; Rev 4) Motors and Generators
NEMA MG 2	(1989) Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators

UNDERWRITERS LABORATORIES (UL)

UL 207	(1993; Rev through Oct 1997) Refrigerant-Containing Components and Accessories, Nonelectrical

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Refrigeration System, **G, ED**.
Drawings.

Drawings shall provide adequate detail to demonstrate compliance with contract requirements. Drawings shall consist of:

(1) Equipment layouts which identify assembly and installation details.

(2) Piping layouts which identify valves, fittings, pipe sizes, and pipe slopes. Changes to the design in any way shall be clearly identified and explained.

(3) Plans and elevations which identify clearances required for maintenance and operation.

(4) Wiring diagrams which identify each component individually and interconnected or interlocked relationships between components.

(5) Foundation drawings, bolt-setting information, and foundation bolts prior to concrete foundation construction for

equipment indicated or required to have concrete foundations.

(6) Details of supports, if other than those indicated, including loadings and type of frames, brackets, stanchions, or other supports.

(7) Automatic temperature control diagrams and control sequences.

(8) Installation details which include the amount of factory set superheat and corresponding refrigerant pressure/temperature.

SD-03 Product Data

Refrigeration System.

Manufacturer's standard catalog data, prior to the purchase or installation of a particular component, shall be highlighted to show brand name, model number, size, options, performance charts and curves, etc. in sufficient detail to demonstrate compliance with contract requirements. Data shall be provided for each specified component. Data shall include manufacturer's recommended installation instructions and procedures. If vibration isolation is specified for a unit, vibration isolator literature shall be included containing catalog cuts and certification that the isolation characteristics of the isolators provided meet the manufacturer's recommendations.

Framed Instructions.

Framed instructions for posting, at least 2 weeks prior to construction completion.

Qualifications

A letter listing the qualifying procedures for each welder. The letter shall include supporting data such as test procedures used, what was tested to, etc. and a list of the names of qualified welders and their identification symbols.

Verification of Dimensions

A letter, at least 2 weeks prior to beginning construction, including the date the site was visited, conformation of existing conditions, and any discrepancies found.

Tests

A letter, at least 10 working days in advance of each test, advising the Contracting Officer of the test. Individual letters shall be submitted for the refrigerant system, the system performance, and the acceptance tests. Each letter shall identify the date, time, and location for each test.

Demonstrations, **G, ED**

A letter, at least 14 working days prior to the date of the proposed training course, which identifies the date, time, and location for the training.

Spare Parts Data

1.2.1 Spare Parts Data

Spare parts data for each different item of equipment specified, after approval of detail drawings and not later than **2** months prior to the date of beneficial occupancy. The data shall include a complete list of parts and supplies, with current unit prices and source of supply, a recommended spare parts list for 1 year of operation, and a list of the parts recommended by the manufacturer to be replaced on a routine basis.

Test Reports

Tests, **G, ED**

Six copies of each test containing the information described below in bound 216 by 279 mm (8-1/2 by 11 inch) booklets. Individual reports shall be submitted for the refrigerant system, the system performance, and the acceptance tests.

(1) The dates the tests were started and completed.

(2) A list of equipment used, with calibration certifications.

(3) Initial test summaries.

(4) Repairs/adjustments performed.

(5) Final test results and comments.

SD-07 Certificates

Refrigeration System.

Where the system, components, or equipment are specified to comply with requirements of ARI, ASHRAE, ASME, or UL, proof of such compliance shall be provided. The label or listing of the specified agency will be acceptable evidence. In lieu of the label or listing, a written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of the specified agency may be submitted. When performance requirements of this project's drawings and specifications vary from standard ARI rating conditions, computer printouts, catalog, or other application data certified by ARI or a nationally recognized laboratory as described above shall be included. If ARI does not have a current certification program that encompasses such application data, the manufacturer may self certify that his application data complies with project performance requirements in accordance with the specified test standards.

Service Organizations.

1.2.2 Service Organizations

A certified list of qualified permanent service organizations for support of the equipment which includes their addresses and qualifications. The

service organizations shall be reasonably convenient to the equipment installation and be able to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.3 DELIVERY, STORAGE, AND HANDLING

Stored items shall be protected from the weather and contamination. Proper protection and care of material before, during, and after installation shall be the Contractor's responsibility. Any materials found to be damaged shall be replaced at the Contractor's expense. During installation, piping and similar openings shall be capped to keep out dirt and other foreign matter.

1.4 PROJECT/SITE CONDITIONS

1.4.1 Verification of Dimensions

The Contractor shall become familiar with all details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work.

1.4.2 Drawings

The Contractor shall investigate the plumbing, fire protection, electrical, structural and finish conditions that would affect the work to be performed and arrange such work accordingly, furnishing required offsets, fittings, and accessories to meet such conditions. Equipment, ductwork, and piping arrangements shall fit into space allotted and allow adequate acceptable clearances for installation, replacement, entry, servicing, and maintenance.

1.5 OPERATION AND MAINTENANCE MANUALS

1.5.1 Operation Manual

Six complete copies of an operation manual in bound 216 x 279 mm (8-1/2 x 11 inch) booklets listing step-by-step procedures required for system startup, operation, and shutdown shall be provided. The booklets shall include the manufacturer's name, model number, parts list, and a brief description of all equipment and their basic operating features.

1.5.2 Maintenance Manual

Six complete copies of maintenance manual in bound 216 x 279 mm (8-1/2 x 11 inch) booklets listing routine maintenance procedures, possible breakdowns and repairs, and a trouble shooting guide shall be provided. The manuals shall include piping and equipment layouts and simplified wiring and control diagrams of the system as installed.

PART 2 PRODUCTS

2.1 STANDARD COMMERCIAL PRODUCTS

Materials and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of such products, which are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2 year use shall include applications of equipment and materials under similar circumstances and of similar size. The 2 years

experience shall be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturer's catalogs, or brochures. Products having less than a 2 year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. Products shall be supported by a service organization. System components shall be environmentally suitable for the indicated locations.

2.2 NAMEPLATES

Major equipment including compressors, condensers, unit coolers, receivers, heat exchanges, fans, and motors shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment. Plates shall be durable and legible throughout equipment life and made of stainless steel. Plates shall be fixed in prominent locations with nonferrous screws or bolts.

2.3 ELECTRICAL WORK

Electrical equipment, motors, motor efficiencies, and wiring shall be in accordance with Section 16415 ELECTRICAL WORK, INTERIOR. Electrical motor driven equipment specified shall be provided complete with motors, motor starters, and controls. Electrical characteristics and enclosure type shall be as shown, and unless otherwise indicated, motors of 1 horsepower and above with open, dripproof, or totally enclosed fan cooled enclosures, shall be high efficiency type. Field wiring shall be in accordance with manufacturer's instructions. Each motor shall conform to NEMA MG 1 and NEMA MG 2 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Motors shall be continuous duty with the enclosure specified. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary for the motor control indicated. Motors shall be furnished with a magnetic across-the-line or reduced voltage type starter as required by the manufacturer. Motor duty requirements shall allow for maximum frequency start-stop operation and minimum encountered interval between start and stop. Motors shall be sized for the applicable loads. Motor torque shall be capable of accelerating the connected load within 20 seconds with 80 percent of the rated voltage maintained at motor terminals during one starting period. Motor bearings shall be fitted with grease supply fittings and grease relief to outside of enclosure. Manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices specified, but not shown, shall be provided. Unit control panels and electrical components shall be mounted in a NEMA ICS 6, Type 1 or 3A enclosure.

2.4 MISCELLANEOUS MATERIALS

2.4.1 Refrigerant and Oil

Refrigerant shall be R-404A. Refrigerant systems shall be charged in accordance with manufacturer's recommendations, including types and quantities of refrigerant and lubricating oil. Except for factory sealed units, two complete charges of lubricating oil for each compressor crankcase shall be furnished. One charge shall be used during the system performance testing period. Following the satisfactory completion of the performance testing, the oil shall be drained and replaced with a second charge.

2.4.2 Gaskets

Gaskets shall conform to ASTM F 104 classification for compressed sheet with nitrile binder and acrylic fibers for maximum 370 degrees C (700 degrees F) service.

2.4.3 Bolts and Nuts

Bolts and nuts, except as required for piping applications, shall conform to ASTM A 307. The bolt head shall be marked to identify the manufacturer and the standard with which the bolt complies, in accordance with ASTM A 307.

2.4.4 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69.

2.4.5 Escutcheons

Escutcheons shall be chromium-plated iron or chromium-plated brass, either one piece or split pattern, held in place by internal spring tension or set screws.

2.4.6 Pressure and Vacuum Gauge

Gauge shall conform to ASME B40.1, Class 1, 2, or 3, Style X, Type I or III as required, 115 mm (4-1/2 inches) in diameter with phenolic or metal case. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle third of the range.

2.4.7 Temperature Gauges

Industrial duty thermometers shall be provided for the required temperature range. Thermometers shall have a Fahrenheit scale on a white face. The pointer shall be adjustable.

2.4.7.1 Stem Cased-Glass

Stem cased-glass case shall be polished stainless steel or cast aluminum, 229 mm (9 inches) long, with clear acrylic lens, and non-mercury filled glass tube.

2.4.7.2 Bimetallic Dial

Bimetallic dial type case shall be not less than 89 mm (3-1/2 inches), stainless steel, and shall be hermetically sealed with clear acrylic lens. Bimetallic element shall be silicone dampened and unit fitted with external calibrator adjustment. Accuracy shall be one percent of dial range.

2.4.7.3 Liquid-, Solid-, and Vapor-Filled Dial

Liquid-, solid-, and vapor-filled dial type cases shall be not less than 89 mm (3-1/2 inches), stainless steel or cast aluminum with clear acrylic lens. Fill shall be nonmercury, suitable for encountered cross-ambients, and connecting capillary tubing shall be double-braided bronze.

2.4.7.4 Thermal Well

Thermal well shall be identical size, 15 or 20 mm (1/2 or 3/4 inch) NPT

connection, brass or stainless steel. Where test wells are indicated, provide captive plug-fitted type 15 mm (1/2 inch) NPT connection suitable for use with either engraved stem or standard separable socket thermometer or thermostat. Extended neck thermal wells shall be of sufficient length to clear insulation thickness by 25 mm.

2.4.8 Unicellular Plastic Foam

Unicellular plastic foam shall be in accordance with ASTM C 534, Type I.

2.4.9 Bird Screen

Screen shall be square mesh, plain weave, 0.79 mm (0.031 inch) diameter stainless steel wire.

2.4.10 Aluminum Sheets and Plates

ASTM B 209, Alloy 3003, H-14. Sheets shall be lockforming quality.

2.4.11 Aluminum Shapes

ASTM B 221, Alloy 6061, T-5 and T-6.

2.5 COMPRESSOR RACK

Compressor unit shall be factory fabricated, assembled, tested, packaged, parrallel multiple compressor refrigeration system with microprocesor based controls and ready for full capacity operation after terminal point connection and field charging with operating fluids. Unit shall conform to ARI 520, ASHRAE 23, and ASHRAE 15.

All compressors and associated accessories shall be factory mounted on a structural steel rack, and shall include receiver, suction and liquid headers, filter, dryers, pressure switches, liquid line solenoid valves, heat recovery, liquid subcooling and all accessories required for a complete and operating system.

2.5.1 Compressor

Compressors shall be selected for maximum energy efficiency and operating reliability. Rotating parts shall be statically and dynamically balanced at the factory to eliminate vibration at both partial and full load conditions. Compressors shall be capable of continuous operation at lowest partial load. Compressor over 7.5 kW (10 hp) shall start from rest unloaded. Compressor unloaders shall not be used when saturated suction temperatures are below minus 4 degrees C (25 degrees F).

2.5.1.1 Construction

Compressors 1.5 kW (2 hp) and less shall be the accessible, sealed reciprocating type of either the open or semi-hermetic design. Compressors above 1.5 kW (2 hp) shall be the accessible hermetic, sealed reciprocating type. Compressors shall have integrally cast housings of close-grained iron with an oil-level bull's eye, cast cylinder heads, cast aluminum or forged steel connecting rods, and cast iron or forged steel crankshafts. Main bearings shall be the sleeve-insert type.

2.5.1.2 Lubrication System

The lubrication system on compressors 2.2 kW (3 hp) or larger shall be the forced-feed, positive-displacement type with oil strainer. The oil pump shall be reversible. Lube oil pressure gauge and failure switch shall be provided for forced-feed lubrication type compressors. Compressor shall be provided with an adjustable oil level regulator with a shutoff valve on each inlet to allow removal of individual compressors without shutting down the entire system.

2.5.1.3 Motor

Compressor motors shall be of the constant-speed, squirrel-cage, induction, hermetically sealed, low-starting-current, high-torque type. Motors shall be furnished with magnetic NEMA across-the-line motor starters and disconnects in general purpose enclosures.

2.5.1.4 Compressor Components

Compressor systems shall include, as a minimum, the following:

a. Compressors 1.1 kW (1-1/2 hp) and larger shall be provided with double seated suction and discharge service valves each with gauge ports.

b. Compressors 3.7 kW (5 hp) or larger shall have a solid state oil pressure safety switch with a manual reset with auxiliary alarm contacts. Time delay duration shall be as recommended by compressor manufacturer.

c. Each compressor shall have a single low-pressure control with automatic reset and adjustable cut-in and cut-out range. Braided steel lines shall be used.

d. Each compressor shall have a single high-pressure control with manual reset, adjustable set-point, and auxiliary alarm contact. Braided steel lines shall be used.

e. A compressor cooling fan shall be provided for each compressor which operates below minus 18 degrees C (0 degrees F) saturated suction temperature.

f. Each compressor shall have a crankcase oil heater. Control of the heaters shall be as recommended by the compressor manufacturer.

g. When required by the compressor manufacturer, compressors shall be provided with a hot-gas muffler to reduce vibration and noise from pulsations.

2.5.2 Base Mounting

Compressor and accommodating components shall be factory mounted on a rigid, steel rack, where indicated. Compressor assembly shall be mounted. Elastomer pads shall placed between the assembly base and the floor. selected to limit transmissibility of imbalanced forces at lowest equipment rpm to 5 percent.

2.5.3 Controls

Each compressor rack shall be provided with a factory mounted and tested microprocessor control panel, programmed to monitor and control compressor

operation, defrost, and system alarms. The unit shall be complete with all operating and safety controls factory mounted for connecting to a remote thermostat. Controls shall include:

a. 24 volt transformer.
b. Interlocking non-fused disconnect
c. Automatic reset thermal controls.
d. Fan motor contactor.
e. Fan delay off thermostat
f. On-off control switch.
g. Individual compressor alarms.
h. System alarms.
i. Remote signal to the building refrigeration alarm panel.

2.5.4 Unit Accessories

Remote condensers shall be in accordance with paragraph CONDENSER. Accessories to be used in combination with each unit shall be provided as indicated and shall be in accordance with paragraph REFRIGERANT ACCESSORIES. Outdoor condensing units shall be provided with weather hoods.

2.5.5 Electrical Controls

Electrical controls for the unit shall be in accordance with paragraph ELECTRICAL WORK and include at a minimum main and branch circuit overload protective devices compensated for ambient temperatures as recommended by the manufacturer; status pilot lights; compressor safety, operating and capacity controls; defrost controls; local and remote audible and visual alarms with provisions to silence; short cycling control with lock-out timer; time delay for sequenced compressor starts; and remote component interface.

2.6 CONDENSER, AIR-COOLED

Unit shall be factory fabricated and tested, packaged, self-contained and ready for full capacity operation after terminal point connections. Unit shall conform to ARI 460. Split systems shall be manufacturer matched units. Fans shall be propeller or centrifugal type as specified in paragraph Fans. Fan motors shall have totally enclosed enclosures. Electrical controls for the unit shall be in accordance with paragraph ELECTRICAL WORK shall include a control transformer and shall be capable of interfacing with local and remote components.

2.6.1 Unit Casing

Casing shall be weatherproof and enclose all unit components. Structural members and sheet metal for the unit casing shall be constructed of galvanized steel or aluminum. Casing shall be fitted with lifting provisions, access panels, removable legs, and fan and heat rejection coil guards and screens.

2.6.2 Condenser Coil

Coil shall have copper tubes of 10 mm (3/8 inch) minimum diameter with copper fins that are mechanically bonded or soldered to the tubes. Coils shall be protected with minimum 0.076 mm (3 mils) thick dipped phenolic or vinyl coating. Casing shall be galvanized steel or aluminum. Contact of dissimilar metals shall be avoided. Coils shall be tested in accordance

with ASHRAE 15 at the factory and shall be suitable for the working pressure of the installed system. Condenser may be used for refrigerant storage in lieu of separate receiver, provided that storage capacity is 20 percent in excess of fully charged system. Coil shall be dehydrated and sealed after testing and prior to evaluation and charging. Unit shall be provided with a factory operating charge of refrigerant and oil or a holding charge. Unit shipped with a holding charge shall be field charged. Separate expansion devices shall be provided for each compressor circuit.

2.7 UNIT COOLERS

Unit shall be forced circulation type, factory fabricated, assembled and tested, and packaged in accordance with ARI 420. Fan shall be the propeller type in accordance with paragraph Fans. Motors shall have totally enclosed enclosures.

2.7.1 Construction

Casing shall be Type 300 stainless steel, aluminum, mill galvanized or hot-dip galvanized steel after fabrication. Zinc-coated carbon steel shall be provided with protective coating. Coils shall have copper tubes and aluminum fins. Drain pan shall be watertight, corrosion resistant. Drainage piping for units in spaces maintained at less than 2 degrees C shall be insulated. Motors shall have permanently lubricated bearings and built-in thermal protection. Fans shall not require a separate electrical circuit. Provide adjustable louvers to direct the air in four directions at a 45 degree angle.

2.7.2 Defrosting

Unit shall be defrosted with ambient space air for refrigerated spaces and fitted with a electric heat defrosting system for freezers.. Defrost system shall be controlled by timer defrost controller adjustable for up to 6 defrost cycles per 24 hours, each of 5 to 120 minutes duration. Controller shall include an adjustable timer to control frequency of cycles; defrost initiating thermostat; adjustable program timer to control sequence of defrost cycle; defrost terminating thermostat; manual override switch; selector switch; and status pilot light.

Unit cooler defrost shall be controlled by the associated compressor unit microprocessor. Provide a factory mounted termination thermostat on each unit and a factory mounted fan delay thermostat on each unit with electric defrost. Unit coolers located in freezer shall be provided with integral condensate pan heaters.

2.8 CONTROLS AND INSTRUMENTS

Refrigeration system controls, instruments and devices shall be industrial quality, and shall conform to applicable requirements of ASHRAE 15. Fluid containing surfaces shall be rated for the service and constructed of materials suitable for the fluid. Component electrical rating shall be 120 volt ac, unless otherwise indicated and shall be suitable for imposed loads.

2.8.1 Refrigeration System Alarms

2.8.1.1 Audible Alarm

Audible alarm shall be surface-mounted, 200 mm (4 inch) vibrating bell type

suitable for indoor or outdoor service.

2.8.1.2 Visual Alarm

Visual alarm shall be pilot light type. Alarm shall be 100 watt, incandescent, vapor-tight fixture with cast metal guard and red lens.

2.8.2 Controllers

2.8.2.1 Differential Pressure Controller

Differential pressure controller shall be provided with high and low pressure sensing ports and shall be direct or reverse acting with calibrated proportional band and set point adjustments. Controller output shall be 4-20 mA dc, proportional to the pressure differential sensed. Local and remote set point adjustments shall be included. Range shall meet system requirements.

2.8.2.2 Differential Temperature Controller

Differential temperature controller shall be provided with two filled, remote sensing bulbs connected to the controller by armored capillary tubing. Controller shall be direct or reverse acting with calibrated proportional band and set point adjustments. Controller output shall be 4-20 mA dc, proportional to the temperature differential sensed. Provisions for local and remote set point adjustments shall be included. Range shall be as required to meet system requirements. For immersion service, thermal wells shall be provided.

2.8.3 Pilot Lights

Panel-mounted pilot lights shall be NEMA Class 12 oil-tight, push-to-test transformer for 6-8 Vac lamps. Lamps shall be replaceable by removal of color cap. Cap color shall be as indicated.

2.8.4 Programmer, Demand Control/Load

Programmer shall be fully automatic, fail safe, field programmable, solid-state, demand control and load programmable for 16 loads. Demand control portion shall monitor power consumption by watt or current transducers. Set point shall be field adjustable with adjustable dead band. Load shedding sequence time and differential time between load shedding shall be adjustable. Contacts shall store alarm condition. Meter readout shall indicate demand deviation from set point. Load profile recorder shall be strip-chart type with readily discernable event record. Load programmer shall permit programming of on/off time of each load for any time element within a week and shall equalize power demand over a preset time cycle. System shall include input override and time cycle accelerator for checkout. Alarm condition, status of all loads and time period shall be visually indicated and recorded. Each load shall include a H-O-A toggle switch. Alarm provisions shall include relay contacts for external, remote alarm functions and test provisions. Override pressure switch shall be provided to restore shedded loads indicated. Control panel enclosure shall be NEMA ICS 6, Type 1, surface mounted type with key lock. Load profile recorder shall be flush panel mounted type. Load relays shall be plug-in type with critical load failure in "on" mode and contacts rated for pilot duty at 120 volt ac. Load shedding position switches shall shed loads on a first shed/last restore basis and remove loads from system logic for shedding cycle. Time clock shall be fitted with spring motor to

maintain time in event of power failure.

2.8.5 Switches, Fluid Service

Switches shall be field adjustable SPDT type and shall have NEMA ICS 6, Type 1 enclosure with operating range specified or indicated. Circuits shall be as required for the applicable functions.

2.8.5.1 Air Flow Switch

Air flow switch shall have a service pressure range of 31 Pa to 2542 Pa (0.12 to 10 inches wg).

2.8.5.2 Pressure Switch

Pressure switch shall be factory set, one or two stage as indicated, with adjustable operating and differential pressure. Bourdon tube inlet shall be fitted with damper screw adjustment.

2.8.5.3 Differential Pressure Switch

Differential pressure switch shall be factory set, provided with high and low sensing ports, one or two stages and adjustable differential range and pressure.

2.8.5.4 Temperature Switch

Temperature switch shall be factory set, provided with capillary armored capillary tubing and filled sensing system, one or two stages as indicated, and operating adjustable differential range. For immersion service, thermal wells shall be provided.

2.8.5.5 Differential Temperature Switch

Differential temperature switch shall be factory set, provided with two separate separate armored capillary systems, one or two stages, and adjustable differential range and temperature. For immersion service, thermal wells shall be provided.

2.8.6 Push-Button Stations

Stations shall be NEMA Class 12 oil-tight, momentary or maintained-contact type, as indicated. Start push-buttons shall have a fully guarded or flush black operator button. Stop push-buttons shall have an unguarded or extended red operator button.

2.8.7 Selector

Switches shall be NEMA Class 12 oil-tight, momentary or maintained contact type, as indicated, with standard operator.

2.9 HEAT RECOVERY DEVICES

2.9.1 Hot Water Reclaim

Unit shall be integral to the compressor rack, double-wall, tube-within-tube heat exchanger type, complete with thermostatic control. Unit shall be constructed and refrigerant pressure/temperature rated in accordance with ASHRAE 15. Heat exchanger coil shall consist of an

external refrigerant containing carbon steel tube and an internal, double-wall-in-metallic contact, convoluted, potable water containing copper tube. Cabinet shall be fabricated of zinc-protected steel and shall be internally insulated in coil space. The recovery device shall be provided with a refrigerant compressor head pressure control and an interlocked, potable water circulating pump. Pump and motor assembly shall be close-coupled, manufacturer's standard type with indicated head and capacity characteristics, and with brass, bronze, copper or stainless steel wetted parts. Pump shall be mounted integral to the exchanger and be rated for 115 volt ac power supply.

2.10 PURGE SYSTEM

Refrigeration systems which operate at pressures below atmospheric pressure shall be provided with a purge system. Purge systems shall automatically remove air, water vapor, and non-condensible gases from the system's refrigerant. Purge systems shall condense, separate, and return all refrigerant back to the system. An oil separator shall be provided with the purge system if required by the manufacturer. Purge system shall not discharge to occupied areas, or create a potential hazard to personnel. Purge system shall include a purge pressure gauge, number of starts counter, and an elapsed time meter. Purge system shall include lights or an alarm which indicate excessive purge or an abnormal air leakage into the system.

2.11 ICE MAKER

Provide a complete, packaged, engineered ice making system, complete with reciprocating or semi-hermetic compressor, refrigeration valves, piping, water circulation pump, fragmentary, cube, or tube ice type ice maker, remote air cooled condenser, ice storage bin with integral agitator, semi-automatic bagger, water filtration system, and all interconnecting piping, wiring and controls. Ice making system shall be furnished by a single supplier who shall be responsible for the matching of the various components and for integration of controls to ensure a complete and operating ice making system. All wetted parts in contact with ice shall be stainless steel. Capacities of the equipment shall be as indicated.

2.12 REFRIGERANT LEAK DETECTOR

Detector shall be the continuously-operating, halogen-specific type. Detector shall be appropriate for the refrigerant in use. Detector shall be specifically designed for area monitoring and shall include 4 sampling points installed where indicated. Detector design and construction shall be compatible with the temperature, humidity, barometric pressure and voltage fluctuations of the operating area. Detector shall have an adjustable sensitivity such that it can detect refrigerant at or above 3 parts per million (ppm). Detector shall be supplied factory-calibrated for the appropriate refrigerant. Detector shall be provided with an alarm relay output which energizes when the detector detects a refrigerant level at or above the TLV-TWA (or toxicity measurement consistent therewith) for the refrigerant in use. The detector's relay should be capable of initiating corresponding alarms and ventilation systems as indicated on the drawings. Detector shall be provided with a failure relay output that energizes when the monitor detects a fault in its operation. Detector shall be compatible with the facility's energy management and control system (EMCS). The EMCS shall be capable of generating an electronic log of the refrigerant level in the operating area, monitoring for detector malfunctions, and monitoring for any refrigerant alarm conditions.

2.13 REFRIGERANT RELIEF VALVE/RUPTURE DISC ASSEMBLY

The assembly shall be a combination pressure relief valve and rupture disc designed for refrigerant usage. The assembly shall be in accordance with ASME BPV IX and ASHRAE 15. The assembly shall be provided with a pressure gauge assembly which will provide local indication if a rupture disc is broken. Rupture disc shall be the non-fragmenting type.

2.14 REFRIGERANT SIGNS

Refrigerant signs shall be a medium-weight aluminum type with a baked enamel finish. Signs shall be suitable for indoor or outdoor service. Signs shall have a white background with red letters not less than 12 mm in height.

2.14.1 Installation Identification

Each new refrigerating system shall be provided with a refrigerant sign which indicates the following as a minimum:

a. Contractor's name
b. Refrigerant number and amount of refrigerant.
c. The lubricant identity and amount.
d. Field test pressure applied.

2.14.2 Controls and Piping Identification

Refrigerant systems containing more than 50 kg of refrigerant shall be provided with refrigerant signs which designate the following as a minimum:

a. Valves or switches for controlling the refrigerant flow , the ventilation system, and the refrigerant compressor.
b. Pressure limiting device.

2.15 POWER TRANSMISSION COMPONENTS

Fan and open compressor drives shall be in accordance with the manufacturer's published recommendations, except as otherwise specified. Horsepower rating of V-belt drive shall be based on maximum pitch diameter of sheaves. Compressors shall be fitted with fixed sheaves and drives with a minimum service factor of 1.5. Where the number of unit starts exceeds 8 per 24 hours, add 0.1 to the required drive service factor. Sheaves shall be statically and dynamically balanced, machined ferrous metal, bushing type, secured by key and keyway. Pitch diameter of fixed pitch sheaves and adjustable sheaves, when adjusted to specific limits, shall be not less than that recommended by NEMA MG 1. Adjustable sheaves shall be selected to provide the required operating speed with the sheave set at mid-point of its adjustment range. The adjustment range for various size and type belts shall be 16 percent minimum for classical section belts and 12 percent minimum for narrow section belts. Belt drive motors shall be provided with slide rail or equivalent adjustable motor bases. Direct drive couplings for motors rated less than 2.2 kW (3 hp) shall be manufacturer's standard. Direct drive couplings for motors rated greater than 2.2 kW (3 hp) shall be elastomer-in-shear type. Each drive shall be independent of any other drive. Drive bearings shall be protected with water slingers or shields. V-belt drives shall be fitted with guards where exposed to contact by personnel.

2.16 DRAIN AND MISCELLANEOUS PIPING

Piping, fittings, valves and accessories for drain and miscellaneous services shall be in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

2.17 PIPING AND FITTINGS, FLUOROCARBONS

Piping, valves, fittings, and accessories shall conform to the requirements of ASHRAE 15and ASME B31.5, except as specified.

2.17.1 Copper Tubing

Copper tubing shall conform to ASTM B 280 annealed or hard drawn as required. Copper tubing shall be soft annealed where bending is required and hard drawn where no bending is required. Soft annealed copper tubing shall not be used in sizes larger than 35 mm (1-3/8 inches). Joints shall be brazed except that joints on lines 22 mm (7/8 inch) and smaller may be flared.

2.17.2 Copper Tube Joints and Fittings

Copper tube joints and fittings shall be flare joint type with short-shank flare, or solder-joint pressure type. Joints and fittings for brazed joint shall be wrought-copper or forged-brass sweat fittings. Cast sweat-type joints and fittings will not be allowed for brazed joints.

2.18 VALVES, FLUOROCARBON

Valves shall be pressure and temperature rated for contained refrigerant service and shall comply with ASME B31.1. Metals of construction shall be of Type 300 stainless steel, or ferrous or copper ferrous based. Atmosphere exposed valve stems shall be stainless steel or corrosion resistant metal plated carbon steel. Valve body connections shall be brazed or welded socket, flanged or combination thereof. Threaded connections shall not be used, except in pilot pressure or gauge lines where maintenance disassembly is required and welded flanges cannot be used. Valves shall be suitable for or fitted with extended copper ends for brazing in-place without disassembly. Ferrous body valves shall be fitted with factory fabricated and brazed copper transitions. To minimize system pressure drops, where practicable, globe valves shall be angle body type, and straight line valves shall be full port ball type. Control valve inlets shall be fitted with integral or adapted strainer or filter where recommended or required by manufacturer. Valves shall be cleaned and sealed moisture-tight.

2.18.1 Refrigerant-Stop Valves

Stop valves shall be designed for use with the refrigerant used and shall have pressure ratings compatible with system working pressures encountered. Gate valves will not be acceptable.

2.18.1.1 Fluorocarbon Service

Valves 16 mm (5/8 inch) and smaller shall be handwheel operated, straight or angle, packless diaphragm globe type with back-seating stem, brazed ends, except where SAE flare or retained seal cap connections are required. Valves larger than 16 mm (5/8 inch) shall be globe or angle type, wrench operated with ground-finish stems, or ball valves, packed especially for refrigerant service, back seated, and provided with seal caps. Refrigerant

isolation and shutoff valves shall have retained or captive spindles and facilities for tightening or replacement of the gland packing under line pressure as applicable. Stop valves shall have back-seating plated steel stem, bolted bonnet in sizes 25 mm (1 inch) OD and larger, integral or flanged transition brazed socket. Valves, in sizes through 65 mm (2-1/2 inches) shall be end-entry body assembly, full-port, floating ball type, with equalizing orifice fitted chrome plated ball, seats and seals of tetrafluoroethylene, chrome plated or stainless steel stem, and seal cap. In sizes 100 mm (4 inch) IPS and larger, and in smaller sizes where carbon steel piping is used, valve bodies shall be tongue and groove flanged and complete with mating flange, gaskets and bolting for socket or butt-weld connection. Purge, charge and receiver valves shall be of manufacturer's standard configuration.

2.18.2 Check Valve

Valve shall be designed for service application, spring-loaded type where required, with resilient seat and with flanged body in sizes 15 mm (1/2 inch) and larger. Valve shall provide positive shutoff at 13.8 kPa (2 psi) psi differential pressure.

2.18.3 Liquid Solenoid Valves

Valves shall comply with ARI 760 and shall be suitable for continuous duty with applied voltages 15 percent under and 5 percent over nominal rated voltage at maximum and minimum encountered pressure and temperature service conditions. Valves shall be direct-acting or pilot-operating type, packless, except that packed stem, seal capped, manual lifting provisions shall be furnished. Solenoid coils shall be moistureproof, UL approved, totally encapsulated or encapsulated and metal jacketed as required. Valves shall have safe working pressure of 2758 kPa (400 psi) and a maximum operating pressure differential of at least 1380 kPa at 85 percent rated voltage. Valves shall have an operating pressure differential suitable for the refrigerant used.

2.18.4 Expansion Valves

Expansion valves shall conform to the requirements of ARI 750. Valve shall be of the diaphragm and spring type with internal or external equalizers, and bulb and capillary tubing. Valve shall be provided with an external superheat adjustment along with a seal cap. Internal equalizers may be utilized where flowing refrigerant pressure drop between outlet of the valve and inlet to the evaporator coil is negligible and pressure drop across the evaporator is less than the pressure difference corresponding to 1 degree C (2 degrees F) of saturated suction temperature at evaporator conditions. Bulb charge shall be determined by the manufacturer for the application and liquid shall remain in the bulb at all operating conditions. Gas limited liquid charged valves and other valve devices for limiting evaporator pressure shall not be used without a distributor or discharge tube or effective means to prevent loss of control when bulb becomes warmer than valve body. Pilot-operated valves shall have a characterized plug to provide required modulating control. A de-energized solenoid valve may be used in the pilot line to close the main valve in lieu of a solenoid valve in the main liquid line. An isolatable pressure gauge shall be provided in the pilot line, at the main valve. Automatic pressure reducing or constant pressure regulating expansion valves may be used only where indicated or for constant evaporator loads. In direct-expansion unit cooler applications, thermostatic expansion valve discharge shall be through distributor and distributing tubes or through a

single tube outlet leading to an orificed header provided by the unit cooler manufacturer, supplying an evaporator coil with not more than four circuits. Distributor orifices shall be sized for application conditions and distributor shall be provided by the thermostatic expansion valve manufacturer as a matched combination to suit evaporator coil circuitry. Where indicated, distributor tube shall be fitted with side inlet for hot gas bypass or defrosting. In single compressor/evaporator combinations, where compressor capacity control is only by on-off cycling, and if recommended by the compressor manufacturer, thermostatic expansion valve shall be furnished with a small bleed passage between inlet and outlet to facilitate equalization of high and low side during off cycle.

2.18.5 Safety Relief Valve

Valve shall be the two-way type. Single type valves shall be used only where indicated. Valve shall bear the ASME code symbol. Valve capacity shall be certified by the National Board of Boiler and Pressure Vessel Inspectors. Valve shall be of an automatically reseating design after activation.

2.18.6 Evaporator Pressure Regulators, Direct-Acting

Valve shall include a diaphragm/spring power assembly, external pressure adjustment with seal cap, and pressure gauge port. Valve shall maintain a constant inlet pressure by balancing inlet pressure on diaphragm against an adjustable spring load. Pressure drop at system design load shall not exceed the pressure difference corresponding to a 1 degree C (2 degrees F) change in saturated refrigerant temperature at evaporator operating suction temperature. Spring shall be selected for indicated maximum allowable suction pressure range.

2.18.7 Refrigerant Access Valves

Refrigerant access valves and hose connections shall conform to ARI 720.

2.18.8 Service Gauge Fittings

Fittings shall be designed for connecting a pressure gauge with a hose fitting. These fittings shall be provided in the suction pipe at each unit cooler.

2.19 REFRIGERANT ACCESSORIES

2.19.1 Fans

Fan wheel shafts shall be supported by either maintenance-accessible lubricated anti-friction block-type bearings, or permanently lubricated ball bearings. Unit fans shall be selected to produce the cfm required at the fan total pressure. Thermal overload protection shall be of the manual or automatic-reset type. Fan wheels or propellers shall be constructed of aluminum or galvanized steel. Centrifugal fan wheel housings shall be of galvanized steel, and both centrifugal and propeller fan casings shall be constructed of aluminum or galvanized steel. Steel elements of fans, except fan shafts, shall be hot-dipped galvanized after fabrication or fabricated of mill galvanized steel. Mill-galvanized steel surfaces and edges damaged or cut during fabrication by forming, punching, drilling, welding, or cutting shall be recoated with an approved zinc-rich compound. Fan wheels or propellers shall be statically and dynamically balanced. Forward curved fan wheels shall be limited to .39 cm. Direct-drive fan

motors shall be of the multiple-speed variety. Centrifugal scroll-type fans shall be provided with streamlined orifice inlet and V-belt drive. Each drive shall be independent of any other drive. Propeller fans shall be direct-drive or V-belt drive type with fixed pitch blades. V-belt driven fans shall be mounted on a corrosion protected drive shaft supported by either maintenance-accessible lubricated anti-friction block-type bearings, or permanently lubricated ball bearings.

2.19.2 Pressure Vessels

Pressure vessels shall conform to ASME BPV VIII Div 1 or UL 207, as applicable for maximum and minimum pressure or temperature encountered. Where referenced publications do not apply, pressure components shall be tested at 1-1/2 times design working pressure. Refrigerant wetted carbon steel surfaces shall be pickled or abrasive blasted free of mill scale, cleaned, dried, charged, and sealed. Where service temperatures below minus 6.7 degrees C (20 degrees F) are encountered, materials of construction shall be low temperature alloy carbon steel.

2.19.2.1 Hot Gas Muffler

Unit shall be selected by the manufacturer for maximum noise attenuation. Units rated for 105.5 kW (30 tons) capacity and under may be field tunable type.

2.19.2.2 Liquid Receiver

Receiver shall be designed, filled, and rated in accordance with the recommendations of ARI 495, except as modified herein. Receiver shall be sized so that it is never filled beyond 80 percent of its total capacity. The remaining 20 percent shall allow for liquid expansion. Receiver shall be provided with a relief valve of capacity and setting in accordance with ASHRAE 15. Receiver shall be fitted to include an inlet pipe; an outlet drop pipe with oil seal and oil drain where necessary; two bulls-eye liquid level sight glass in same vertical plane, 90 degrees apart and perpendicular to axis of receiver or external gauge glass with metal guard and automatic stop valves; a thermal well for thermostat; a float switch column; purge, charge, equalizing, pressurizing, plugged drain and service valves on the inlet and outlet connections. Receiver shall be factory insulated with not less than 25 mm thick, 100 percent adhesive bonded, vaportight, flexible, closed-cell elastomer and finished with two coats of solvent base PVC protective coating or 0.41 mm (0.016 inch) thick aluminum jacket.

2.19.2.3 Oil Separator

Separator shall be the high efficiency type, provided with removable flanged head for ease in removing float assembly and removable screen cartridge assembly. Pressure drop through a separator shall not exceed 69 kPa (10 psi) during the removal of hot gas entrained oil. Connections to compressor shall be as recommended by the compressor manufacturer. Separator shall be provided with an oil float valve assembly or needle valve and orifice assembly, drain line shutoff valve, sight glass, filter for removal of all particulate sized 0.01 mm and larger, thermometer and low temperature thermostat fitted to thermal well, immersion heater, and strainer.

2.19.2.4 Oil Reservoir

Reservoir capacity shall equal one charge of all connected compressors. Reservoir shall be provided with an external liquid gauge glass, plugged drain, and isolation valves. Vent piping between the reservoir and the suction header shall be provided with a 34.5 kPa (5 psi) pressure differential relief valve. Reservoir shall be provided with the manufacturer's standard filter on the oil return line to the oil level regulators.

2.19.3 Condenser and Head Pressure Control

Unit shall be capable of automatically operating without daily or seasonal adjustments in ambient temperature of 20 degrees C. Control shall be set for refrigerant condensing temperature of 52 degrees C. Controls shall permit proper operation of system with proper differential pressure across the thermostatic expansion valve. Control system shall be based on sensing of actual condensing pressure in conjunction with manufacturer's standard method of subcooling the saturated refrigerant. Controls shall be set to produce a minimum 15 degrees C subcooling. Subcooling circuit shall be liquid sealed. Air volume control will not be acceptable for ambient conditions below 2 degrees C. Necessary accessories shall be provided to maintain safe compressor discharge temperatures for low temperature systems.

2.19.4 Filter Driers

Driers shall conform to ARI 710. Sizes 16 mm (5/8 inch) and larger shall be the full flow, replaceable core type. Sizes 15 mm (1/2 inch) and smaller shall be the sealed type. Cores shall be of suitable desiccant that will not plug, cake, dust, channel, or break down, and shall remove water, acid, and foreign material from the refrigerant. Filter driers shall be constructed so that none of the desiccant will pass into the refrigerant lines. Minimum bursting pressure shall be 10 MPa (1,500 psig).

2.19.5 Sight Glass and Liquid Level Indicator

2.19.5.1 Assembly and Components

Assembly shall be pressure- and temperature-rated and constructed of materials suitable for the service. Glass shall be borosilicate type. Ferrous components subject to condensation shall be electro-galvanized.

2.19.5.2 Gauge Glass

Gauge glass shall include top and bottom isolation valves fitted with automatic checks, and packing followers; red-line or green-line gauge glass; elastomer or polymer packing to suit the service; and gauge glass guard.

2.19.5.3 Bulls-Eye and Inline Sight Glass Reflex Lens

Bulls-eye and inline sight glass reflex lens shall be provided for dead-end liquid service. For pipe line mounting, two plain lenses in one body suitable for backlighted viewing shall be provided.

2.19.5.4 Moisture Indicator

Indicator shall be a self-reversible action, moisture reactive, color changing media. Indicator shall be furnished with full-color-printing tag containing color, moisture and temperature criteria. Unless otherwise indicated, the moisture indicator shall be an integral part of each

corresponding sight glass.

2.19.6 Flexible Pipe Connectors

Connector shall be pressure and temperature rated for the service in accordance with ASHRAE 15 and ASME B31.5. Connector shall be a composite of interior corrugated phosphor bronze or Type 300 series stainless steel, as required for fluid service, with exterior reinforcement of bronze, stainless steel or monel wire braid. Assembly shall be constructed with a safety factor of not less than 4 at 150 degrees C (300 degrees F). Unless otherwise indicated, the length of a flexible connector shall be as recommended by the manufacturer for the service intended.

2.19.7 Strainers

Strainers used in refrigerant service shall have brass or cast iron body, Y or angle pattern, cleanable, not less than 60-mesh noncorroding screen of an area to provide net free area not less than 10 times the pipe diameter with pressure rating compatible with the refrigerant service. Screens shall be stainless steel or monel and reinforced spring-loaded where necessary for bypass-proof construction.

2.19.8 Brazing Materials

Brazing materials for refrigerant piping shall be in accordance with AWS A5.8, Classification BCuP-5.

2.19.9 Liquid and Suction Headers

Liquid and suction headers shall be provided on each multi-compressor system. Headers shall be sized according to manufacturer's recommendations. Each header shall be provided with service valves to permit servicing each unit cooler and forced circulation air coil. Each service valve shall have a gauge port which can be closed by back-seating the valve and a front seat which can close off the line connected to the manifold. Each service valve shall be provided with a removable, protective valve stem cap or cover.

2.20 FABRICATION

2.20.1 Factory Coating

Unless otherwise specified, equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish, except that items located outside of buildings shall have weather resistant finishes that will withstand 125 500 hours exposure to the salt spray test specified in ASTM B 117 using a 25 percent sodium chloride solution. Immediately after completion of the test, the specimen shall show no signs of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust creepage beyond 3 mm on either side of the scratch mark. Cut edges of galvanized surfaces where hot-dip galvanized sheet steel is used shall be coated with a zinc-rich coating conforming to ASTM D 520, Type I.

2.20.2 Field Painting

Painting required for surfaces not otherwise specified, and finish painting of items only primed at the factory are specified in Section 09900PAINTING, GENERAL.

2.20.2.1 Color Coding

Color coding for piping identification is specified in Section 09900 PAINTING, GENERAL.

2.20.2.2 Color Coding Scheme

A color coding scheme for locating hidden piping shall be in accordance with Section 15400 PLUMBING, GENERAL PURPOSE.

2.21 ELECTRIC HEAT TRACING

Furnish and install a complete UL listed system of heaters, components, and controls to prevent condensate drain lines from freezing. The self-regulating heater shall consist of two (2) 16 AWG nickel coated-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heater to be crossed over its elf without overheating, to be used directly on plastic pipe, and to be cut to length in the field. The heater shall be covered by a radiation cross-linked modified polyolefin dielectric jacket. For installation on plastic piping, the heater shall be applied using aluminum tape, to provide a good ground path where none exist. The heater shall operate on 120 volts without the use of a transformer. The heater shall have a heater output rating of 5 watts per foot at 50 degrees F. Power connection, end seal, splice and tee kit components shall be applied in the field.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be performed in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements. The design, fabrication, and installation of the system shall conform to ASME BPV VIII Div 1 and ASME BPV IX as applicable. Where applicable, work shall be performed in accordance with ASHRAE 15 and IIAR 2 for ammonia systems.

3.1.1 Equipment

Equipment shall be properly leveled, aligned, and secured in place in accordance with manufacturer's instructions. Necessary supports shall be provided for all equipment, appurtenances, and pipe as required, including frames or supports for compressors, pumps and similar items. Compressors shall be isolated from the building structure. Isolators shall be selected and sized based on load-bearing requirements and the lowest frequency of vibration to be isolated. Foundation drawings, bolt-setting information, and foundation bolts shall be furnished prior to concrete foundation construction for equipment indicated or required to have concrete foundations. Concrete for foundations shall be as specified in Section 03300 CAST-IN-PLACE STRUCTURAL CONCRETE.

3.1.2 Mechanical Room Ventilation

Mechanical ventilation systems shall be in accordance with Section 15895 AIR-SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEMS.

3.1.3 Building Surface Penetrations

Sleeves in nonload bearing surfaces shall be galvanized sheet metal, conforming to ASTM A 653/A 653M, Coating Class G-90, 1 mm (20 gauge). Sleeves in load bearing surfaces shall be uncoated carbon steel pipe, conforming to ASTM A 53, Standard weight. Sealants shall be applied to moisture and oil-free surfaces and elastomers to not less than 13 mm depth. Sleeves shall not be installed in structural members.

3.1.3.1 General Service Areas

Each sleeve shall extend through its respective wall, floor, or roof, and shall be cut flush with each surface. Pipes passing through concrete or masonry wall or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall provide a minimum of 6 mm all-around clearance between bare pipe and sleeves or between jacketed-insulation and sleeves. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over-insulation and sleeve shall be sealed in accordance with Section 07900 JOINT SEALING.

3.1.3.2 Waterproof Penetrations

Pipes passing through roof or floor waterproofing membrane shall be installed through a 0.48 kg (17 ounce) copper sleeve or a 0.81 mm (0.032 inch) thick aluminum sleeve, each within an integral skirt or flange. Flashing sleeve shall be suitably formed, and skirt or flange shall extend not less than 200 mm from the pipe and shall be set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing sleeve shall extend up the pipe a minimum of 50 mm above the roof or floor penetration. The annular space between the flashing sleeve and the bare pipe or between the flashing sleeve and the metal-jacket-covered insulation shall be sealed as indicated. Penetrations shall be sealed by either one of the following methods.

a. Waterproof Clamping Flange: Pipes up to and including 250 mm (10 inches) in diameter passing through roof or floor waterproofing membrane may be installed through a cast iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess.

b. Modular Mechanical Type Sealing Assembly: In lieu of a waterproof clamping flange, a modular mechanical type sealing assembly may be installed. Seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. Links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolt shall cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameter.

3.1.3.3 Fire-Rated Penetrations

Penetration of fire-rated walls, partitions, and floors shall be sealed as specified in Section 07840 FIRESTOPPING.

3.1.3.4 Escutcheons

Finished surfaces where exposed piping, bare or insulated, pass through floors, walls, or ceilings, except in boiler, utility, or equipment rooms, shall be provided with escutcheons. Where sleeves project slightly from floors, special deep-type escutcheons shall be used. Escutcheon shall be secured to pipe or pipe covering.

3.1.4 Access Panels

Access panels shall be provided for concealed valves, vents, controls, and items requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced and maintained or completely removed and replaced. Access panels shall be as specified in Section 05500 MISCELLANEOUS METALS.

3.1.5 Refrigeration Piping

Unless otherwise specified, pipe and fittings installation shall conform to the requirements of ASME B31.5. Pipe shall be cut accurately to the measurements established at the jobsite and worked into place without springing or forcing. Cutting or otherwise weakening of the building structure to facilitate piping installation will not be permitted without written approval. Pipes shall be cut square, shall have burrs removed by reaming, and be installed in a manner to permit free expansion and contraction without damage to joints or hangers. Filings, dust, or dirt shall be wiped from interior of pipe before connections are made.

3.1.5.1 Directional Changes

Changes in direction shall be made with fittings, except that bending of pipe 100 mm (4 inches) and smaller will be permitted, provided a pipe bender is used and wide-sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, or other malformations will not be accepted.

3.1.5.2 Functional Requirements

Piping shall be sloped 13 mm per 3 m of pipe in the direction of flow to ensure adequate oil drainage. Open ends of refrigerant lines or equipment shall be properly capped or plugged during installation to keep moisture, dirt, or other foreign material out of the system. Piping shall remain capped until installation. Equipment piping shall be in accordance with the equipment manufacturer's recommendations and the contract drawings.

3.1.5.3 Brazed Joints

Brazing shall be performed in accordance with AWS Brazing Hdbk, except as modified herein. During brazing, the pipe and fittings shall be filled with a pressure regulated inert gas, such as nitrogen, to prevent the formation of scale. Before brazing copper joints, both the outside of the tube and the inside of the fitting shall be cleaned with a wire fitting brush until the entire joint surface is bright and clean. Brazing flux shall not be used. Surplus brazing material shall be removed at all joints. Steel tubing joints shall be made in accordance with the manufacturer's recommendations. Tubing shall be protected against

oxidation during brazing by continuous purging of the inside of the piping using nitrogen. Piping shall be supported prior to brazing and shall not be sprung or forced.

3.1.5.4 Threaded Joints

Threaded joints shall be made with tapered threads and made tight with PTFE tape complying with ASTM D 3308 or equivalent thread-joint compound applied to the male threads only. Not more than three threads shall show after the joint is made.

3.1.5.5 Flanged Joints

Flanged joints shall be assembled square and tight with matched flanges, gaskets, and bolts. Gaskets shall be suitable for use with the refrigerants to be handled. When steel refrigerant piping is used, union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment requiring maintenance, such as compressors, coils, refrigeration equipment, control valves, and other similar items.

3.1.5.6 Flared Connections

When flared connections are used, a suitable lubricant shall be used between the back of the flare and the nut in order to avoid tearing the flare while tightening the nut.

3.1.6 Piping Supports

Refrigerant pipe supports shall conform to ASME B31.5. Hangers used to support piping 50 mm (2 inches) and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Piping subjected to vertical movement, when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers.

3.1.6.1 Seismic Requirements

Piping and attached valves shall be supported and braced to resist seismic loads as specified in Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT. Structural steel required for reinforcement to properly support piping, headers, and equipment but not shown shall be provided. Material used for support shall be as specified in Section 05500 MISCELLANEOUS METALS.

3.1.6.2 Structural Attachments

Attachment to building structure concrete and masonry shall be by cast-in-concrete inserts, built-in anchors, or masonry anchor devices. Inserts and anchors shall be applied with a safety factor not less than 5. Supports shall not be attached to metal decking. Masonry anchors for overhead applications shall be constructed of ferrous materials only. Material used for support shall be as specified in Section 05500 MISCELLANEOUS METALS.

3.1.7 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein. Pipe hanger types 5, 12, and 26 shall not be used.

3.1.7.1 Hangers

Type 3 shall not be used on insulated piping. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.1.7.2 Inserts

Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustments may be used if they otherwise meet the requirements for Type 18 inserts.

3.1.7.3 C-Clamps

Type 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices, furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

3.1.7.4 Angle Attachments

Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adapter.

3.1.7.5 Saddles and Shields

Where Type 39 saddle or Type 40 shield are permitted for a particular pipe attachment application, the Type 39 saddle, connected to the pipe, shall be used on all pipe 100 mm (4 inches) and larger when the temperature of the medium is 16 degrees C or higher. Type 40 shields shall be used on all piping less than 100 mm (4 inches) and all piping 100 mm (4 inches) and larger carrying medium less than 16 degrees C. A high density insulation insert of cellular glass shall be used under the Type 40 shield for piping 50 mm (2 inches) and larger.

3.1.7.6 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69. A support shall be installed not over 25 mm from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1525 mm apart at valves. Pipe hanger loads suspended from steel joist with hanger loads between panel points in excess of 23 kg (50 pounds) shall have the excess hanger loads suspended from panel points.

3.1.7.7 Vertical Pipe Supports

Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4570 mm, not more than 2440 mm from end of risers, and at vent terminations.

3.1.7.8 Pipe Guides

Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides shall be provided where required to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

3.1.7.9 Steel Slides

Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm (4 inches) and larger, a Type 39 saddle shall be used. On piping under 100 mm (4 inches), a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

3.1.7.10 High Temperature Guides with Cradles

Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm (4 inches), or by an amount adequate for the insulation, whichever is greater.

3.1.7.11 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for an individual pipe in the multiple pipe run.

3.1.8 Pipe Alignment Guides

Pipe alignment guides shall be provided where indicated for expansion loops, offsets, and bends and as recommended by the manufacturer for expansion joints, not to exceed 1525 mm on each side of each expansion joint, and in lines 100 mm (4 inches) or smaller not more than 610 mm on each side of the joint.

3.1.9 Pipe Anchors

Anchors shall be provided wherever necessary or indicated to localize expansion or to prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline. Where pipe and conduit penetrations of vapor barrier sealed surfaces occur, these items shall be anchored immediately adjacent to each penetrated surface, to provide essentially zero movement within penetration seal. Detailed drawings of pipe anchors shall be submitted for approval before installation.

3.1.10 Piping Identification

Each piping system and direction of fluid flow shall be identified in accordance with applicable provisions of ANSI A13.1 with color coded, water, moisture and broad-spectrum temperature resistant, plastic labels.

3.1.11 Manual Valves

Stop valves shall be installed on each side of each piece of equipment such as compressors, condensers, evaporators, receivers, and other similar items in multiple-unit installation, to provide partial system isolation as required for maintenance or repair. Angle and globe valves shall be

installed with stems horizontal unless otherwise indicated. Ball valves shall be installed with stems positioned to facilitate operation and maintenance. Isolating valves for pressure gauges and switches shall be external to thermal insulation. Safety switches shall not be fitted with isolation valves. Thermal wells for insertion thermometers and thermostats shall extend beyond thermal insulation surface not less than 25 mm. Filter dryers having access ports may be considered a point of isolation. Purge valves shall be provided at all points of systems where accumulated noncondensible gases would prevent proper system operation. Valves shall be furnished to match line size, unless otherwise indicated or approved. Drain valves shall be provided in bottom of risers and low points of ammonia piping.

3.1.12 Expansion Valves

Expansion valves shall be installed with the thermostatic expansion valve bulb located on top of the suction line when the suction line is less than 50 mm (2 inches) in diameter and at the 4 o'clock or 8 o'clock position on lines larger than 50 mm (2 inches). The bulb shall be securely fastened with two clamps. The bulb shall be insulated. The bulb shall be installed in a horizontal portion of the suction line, if possible, with the pigtail on the bottom. If the bulb is installed in a vertical line, the bulb tubing shall be facing up.

3.1.13 Valve Identification

Each system valve, including those which are part of a factory assembly, shall be tagged. Tags shall be in alphanumeric sequence, progressing in direction of fluid flow. Tags shall be embossed, engraved, or stamped plastic or nonferrous metal of various shapes, sized approximately 35 mm diameter, or equivalent dimension, substantially attached to a component or immediately adjacent thereto. Tags shall be attached with nonferrous, heavy duty, bead or link chain, 14 gauge annealed wire, nylon cable bands or as approved. Tag numbers shall be referenced in Operation and Maintenance Manuals and system diagrams.

3.1.14 Strainers

Strainers shall be provided immediately ahead of solenoid valves and expansion devices and where indicated. Strainers may be an integral part of the expansion valve.

3.1.15 Filter Dryer

A liquid line filter dryer shall be provided on each refrigerant circuit located so that all liquid refrigerant passes through a filter dryer. Dryers shall be sized in accordance with the manufacturer's recommendations. A dryer shall be installed so that it can be isolated from the system, the isolated portion of the system evacuated, and the filter dryer replaced. Dryers shall be installed in the horizontal position except replaceable core filter dryers may be installed in the vertical position with the access flange on the bottom.

3.1.16 Sight Glass

A moisture indicating sight glass shall be installed in refrigerant circuits down stream of filter dryers and where indicated. Sight glass shall be full line size.

3.1.17 Thermometers

Thermometers shall be fitted with thermal well. Where test thermometer locations are indicated, only plugged thermal well shall be provided. Thermometers located within 1525 mm of floor may be rigid stem type. Where thermal well is located above 1525 mm above floor, thermometer shall be universal adjustable angle type or remote element type to 2135 mm above floor and remote element type where thermal well is 2135 mm or more above floor. Thermometers shall be located in coolant supply and return or waste lines at each heat exchanger, at each automatic temperature control device without an integral thermometer, refrigerant liquid line leaving receiver, refrigerant suction line at each unit cooler, and where indicated or required for proper operation of equipment.

3.1.18 Flexible Connectors

Flexible metallic connectors shall be installed perpendicular to line of motion being isolated. Piping for equipment with bidirectional motion shall be fitted with two flexible connectors, in perpendicular planes. Reinforced elastomer flexible connectors shall be installed in accordance with manufacturer's instructions. Piping guides and restraints related to flexible connectors shall be provided as required. Connectors shall be provided in the suction and discharge lines on spring mounted compressors. Connectors shall be anchored firmly at the upstream end on the suction line and the downstream end in the discharge line.

3.1.19 Power Transmission Components Adjustment

V-belts and sheaves shall be properly aligned and tensioned preliminary to operation and after 72 hours of operation at final speed. Belts on drive side shall be uniformly loaded, not bouncing. Alignment of direct-drive couplings shall be to within 50 percent of manufacturer's maximum allowable range of misalignment.

3.1.20 Unit Cooler Drainage

Drain lines from product storage spaces maintained at 2 degrees C or lower shall be fitted with NSF approved connections and cleanout tee; shall be short as possible; shall not be trapped; and shall not be combined, unless all combined units are defrosted simultaneously and are controlled by a single timer. Drain lines may be combined in spaces maintained at nonfreezing temperatures after individual trapping. Drain lines shall be heat traced and insulated starting with drain pan fitting through the surface penetration into a nonfreezing space, a distance sufficient to ensure freedom from ice during defrost cycle. Drain line size shall be not less than drain pan outlet size. Drain line shall be pitched as shown, and not less than 6 mm per 300 mm where not shown. Drain line heat tracing shall be electric as indicated. Electrically heat traced drain lines shall utilize external or internal to drain line heating elements, applied to produce watt-density and temperature recommended by the manufacturer. Where metallic sheathed heat tracer is used in contact with metallic drain line or internal thereto, sheath material shall be stainless steel. External metallic sheathing shall be installed by banding on not more than 300 mm centers with all stainless steel worm drive hose clamps and heat transfer area shall be increased by continuous tangential fillets of heat conducting paste. Electric heat tracing power supply shall be as indicated.

3.1.21 Field Applied Insulation

Field applied insulation shall be as specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.22 Electric Heat Tracing

Apply the heater strip linearly on the pipe after piping has been successfully pressure tested. Secure the heater to piping with cable ties or fiberglass tape. Apply "ELECTRIC TRACED" signs to the outside of the thermal insulation. After installation and before and after installing the thermal insulation, subject heat to testing using a 2500 VDC megger. Minimum insulation resistance should be 20 megohms regardless of length. The installer shall test for both heating cable bus wires to verify the connection of any splices or tees.

3.1.23 Factory Applied Insulation

Suction headers, liquid receivers, oil separators, and oil reservoirs shall be insulated with not less than 19 mm (3/4 inch) thick unicellular plastic foam as a standard manufacturer's process.

3.1.24 Framed Instructions

Framed instructions shall be framed under glass or laminated plastic and posted where directed. Instructions shall include equipment layout, wiring and control diagrams, piping, valves and control sequences, and typed condensed operation instructions. The condensed operation instructions shall include preventative maintenance procedures, methods of checking the system for normal and safe operation, and procedures for safely starting and stopping the system. The instructions shall be posted before acceptance testing of the system.

3.2 TESTS

Tests shall be conducted in the presence of the Contracting Officer. Utilities for testing shall be provided as specified in the SPECIAL CONTRACT REQUIREMENTS. Water and electricity required for the tests will be furnished by the Government. Material, equipment, instruments, and personnel required for the test shall be provided by the Contractor. The services of a qualified technician shall be provided as required to perform tests and procedures indicated. Field tests shall be coordinated with Section 15990 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS.

3.2.1 Refrigerant System

After all components of the refrigerant system have been installed and connected, the entire refrigeration system shall be subjected to a pneumatic test as specified.

3.2.1.1 Preliminary Procedures

Prior to pneumatic testing, equipment which has been factory tested and refrigerant charged as well as equipment which could be damaged or cause personnel injury by imposed test pressure, positive or negative, shall be isolated from the test pressure or removed from the system. Safety relief valves and rupture discs, where not part of factory sealed systems, shall be removed and openings capped or plugged.

3.2.1.2 Pneumatic Test

Pressure control and excess pressure protection shall be provided at the source of test pressure. Valves shall be wide open, except those leading to the atmosphere. Test gas shall be dry nitrogen, with minus 56.7 degrees C (minus 70 degrees F) dewpoint and less than 5 ppm oil. Test pressure shall be applied in two stages before any refrigerant pipe is insulated or covered. First stage test shall be at 69 kPa with every joint being tested with a thick soap or color indicating solution. Second stage tests shall raise the system to the minimum refrigerant leakage test pressure specified in ASHRAE 15 or IIAR 2 with a maximum test pressure of 25 percent greater than specified. Pressure above 690 kPa (100 psig) shall be raised in 10 percent increments with a pressure acclimatizing period between increments. The initial test pressure shall be recorded along with the ambient temperature to which the system is exposed. Final test pressures of the second stage shall be maintained on the system for a minimum of 24 hours. At the end of the 24 hour period, the system pressure shall be recorded along with the ambient temperature to which the system is exposed. A correction factor of 2 kPa will be allowed for each degree change between test space initial and final ambient temperature, plus for increase and minus for a decrease. If the corrected system pressure is not exactly equal to the initial system test pressure, the system shall be investigated for leaking joints. To repair leaks, the joint shall be taken apart, thoroughly cleaned, and reconstructed as a new joint. Joints repaired by caulking, remelting, or back-welding/brazing will not be acceptable. Following repair, the entire system shall be retested using the pneumatic tests described above. The entire system shall be reassembled once the pneumatic tests are satisfactorily completed.

3.2.1.3 Evacuation Test

Following satisfactory completion of the pneumatic tests, the pressure shall be relieved and the entire system shall be evacuated to an absolute pressure of 300 microns. During evacuation of the system, the ambient temperature shall be higher than 2 degrees C (35 degrees F). No more than one system shall be evacuated at one time by one vacuum pump. Once the desired vacuum has been reached, the vacuum line shall be closed and the system shall stand for 1 hour. If the pressure rises over 500 microns after the 1 hour period, the system shall be evacuated again down to 300 microns and let set for another 1 hour period. The system shall not be charged until a vacuum of at least 500 microns is maintained for a period of 1 hour without the assistance of a vacuum line. If, during the testing, the pressure continues to rise, the system shall be checked for leaks, repaired as required, and the evacuation procedure repeated. During evacuation, pressures shall be recorded by a thermocouple type, electronic type, or a calibrated-micron type gauge.

3.2.1.4 System Charging and Startup Test

Following satisfactory completion of the evacuation tests, the system shall be charged with the required amount of refrigerant by raising pressure to normal operating pressure, and in accordance with manufacturer's procedures. Following charging, the system shall operate with high-side and low-side pressures and corresponding refrigerant temperatures, at design or improved values. The entire system shall be tested for leaks. Fluorocarbon systems shall be tested with halide torch or electronic leak detectors.

3.2.1.5 Refrigerant Leakage

If a refrigerant leak is discovered after the system has been charged, the

leaking portion of the system shall immediately be isolated from the remainder of the system and the refrigerant pumped into the system receiver or other suitable container. The refrigerant shall not be discharged into the atmosphere.

3.2.1.6 Contractor's Responsibility

The Contractor shall, at all times during the installation and testing of the refrigeration system, take steps to prevent the release of refrigerants into the atmosphere. The steps shall include, but not be limited to, procedures which will minimize the release of refrigerants to the atmosphere and the use of refrigerant recovery devices to remove refrigerant from the system and store the refrigerant for reuse or reclaim. No more than 85 grams of refrigerant shall be released to the atmosphere in any one occurrence. System leaks within the first year shall be repaired in accordance with the requirements herein at no cost to the Government, including material, labor, and refrigerant, if the leak is the result of defective equipment, material, or installation.

3.2.2 System Performance

After the foregoing tests have been completed and before each refrigeration system is accepted, tests to demonstrate the general operating characteristics of all equipment shall be conducted by a registered professional engineer or an approved manufacturer's startup representative experienced in system startup and testing, at such times as directed. Tests shall cover a period of not less than 5 days for each system and demonstrate that the entire system is functioning in accordance with the drawings and specifications. Corrections and adjustments shall be made as necessary and tests shall be re-conducted to demonstrate that the entire system is functioning as specified. Any refrigerant lost during the system startup shall be replaced. During the system performance tests, a report shall be maintained to document compliance with the specified performance criteria upon completion and testing of the system. The report shall include the following information at a minimum and shall be taken at least three different times at outside dry-bulb temperatures that are at least 3 degrees C apart:

a. Date and outside weather conditions.

b. The load on the system based on the following:
   (1) The refrigerant used in the system.
   (2) Condensing temperature and pressure.
   (3) Suction temperature and pressure.
   (4) Ambient, condensing and coolant temperatures.
   (5) Running current, voltage and proper phase sequence for each phase of all motors.

c. The actual onsite setting of operating and safety controls.

d. Thermostatic expansion valve superheat-value as determined by field test.

e. Subcooling.

f. High and low refrigerant temperature switch set-points.

g. Low oil pressure switch set-point.

h. Defrost system timer and thermostat set-points.

i. Moisture content.

j. Capacity control set-points.

k. Field data and adjustments which affect unit performance and energy consumption.

l. Field adjustments and settings which were not permanently marked as an integral part of a device.

3.2.3 Acceptance Tests

Upon completion and prior to acceptance of the work, the Contractor shall perform pre-operational checkout, calibration and adjustment of system components to ensure and demonstrate stable, accurate, reproducible, energy efficient operation and optimum performance. Systems shall be operated for 48 hours after all major corrections have been made. If tests do not demonstrate satisfactory system performance, deficiencies shall be corrected and system shall be retested. Prior to acceptance, service valve seal caps and blanks over gauge points shall be installed and tightened.

3.3 CLEANING AND ADJUSTING

Equipment shall be wiped clean, with all traces of oil, dust, dirt, or paint spots removed. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed.

3.4 DEMONSTRATIONS

Demonstrations shall be conducted for the operating staff as designated by the Contracting Officer. Demonstrations shall start after the system is functionally completed but prior to final acceptance tests. Demonstrations shall be under the direction of a registered professional engineer who shall attest to installed systems and equipment compliance with the requirements of the contract documents. Demonstrations shall include operation of systems equipment and controls through normal ranges and sequences and simulation of abnormal conditions. Each device shall be caused to function manually and automatically in accordance with its purpose. The field instructions shall cover the items contained in the Operation and Maintenance Manuals as well as demonstrations of routine maintenance operations.

-- End of Section --

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DIVISION 15 - MECHANICAL

SECTION 15895

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM

-- End of Section Table of Contents --

SECTION 15895

AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AIR CONDITIONING AND REFRIGERATION INSTITUTE (ARI)

ARI Guideline D	(1996) Application and Installation of Central Station Air-Handling Units

AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)

AMCA 210	(1985) Laboratory Methods of Testing Fans for Rating
AMCA 300	(1996) Reverberant Room Method for Sound Testing of Fans

AMERICAN BEARING MANUFACTURERS ASSOCIATION (AFBMA)

AFBMA Std 9	(1990) Load Ratings and Fatigue Life for Ball Bearings
AFBMA Std 11	(1990) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53/A 53M	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 123/A 123M	(1997ael) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 924/A 924M	(1999) General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process
ASTM B 62	(1993) Composition Bronze or Ounce Metal Castings
ASTM B 75M	(1999) Seamless Copper Tube (Metric)
ASTM B 88	(1999) Seamless Copper Water Tube

ASTM B 88M	(1999) Seamless Copper Water Tube (Metric)
ASTM B 117	(1997) Operating Salt Spray (Fog) Apparatus
ASTM D 520	(1984; R 1995el) Zinc Dust Pigment
ASTM D 1654	(1992) Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
ASTM D 3359	(1997) Measuring Adhesion by Tape Test
ASTM E 437	(1992; R 1997) Industrial Wire Cloth and Screens (Square Opening Series)

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 52.1	(1992) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter
ASHRAE 70	(1991) Method of Testing for Rating the Performance of Air Outlets and Inlets

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.18	(1984; R 1994) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.22	(1995; B16.22a1998) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1	(1998) Motors and Generators

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1999) Installation of Air Conditioning and Ventilating Systems

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA HVAC Duct Const Stds	(1995; Addenda Nov 1997) HVAC Duct Construction Standards - Metal and Flexible
SMACNA Install Fire Damp HVAC	(1992) Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems
SMACNA Leakage Test Mnl	(1985) HVAC Air Duct Leakage Test Manual

UNDERWRITERS LABORATORIES (UL)

UL 181	(1996; Rev Dec 1998) Factory-Made Air Ducts and Air Connectors
UL 214	(1997) Tests for Flame-Propagation of Fabrics and Films
UL 555	(1999) Fire Dampers
UL 900	(1994; Rev thru Nov 1999) Test Performance of Air Filter Units
UL Bld Mat Dir	(1999) Building Materials Directory
UL Fire Resist Dir	(1999) Fire Resistance Directory (2 Vol.)

1.2 COORDINATION OF TRADES

Ductwork, piping offsets, fittings, and accessories shall be furnished as required to provide a complete installation and to eliminate interference with other construction.

1.3 DELIVERY AND STORAGE

Equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, or other contaminants.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Drawings
Installation

1.4.1 Drawings

Drawings shall consist of equipment layout including assembly and installation details and electrical connection diagrams; ductwork layout showing the location of all supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of all guides and anchors, the load imposed on each support or anchor, and typical support details. Drawings shall include any information required to demonstrate that the system has been coordinated and will properly function as a unit and shall show equipment relationship to other parts of the work, including clearances required for operation and maintenance.

SD-03 Product Data

Components and Equipment

Manufacturer's catalog data shall be included with the detail

drawings for the following items. The data shall be highlighted to show model, size, options, etc., that are intended for consideration. Data shall be adequate to demonstrate compliance with contract requirements for the following:

a. Piping Components

b. Ductwork Components

c. Air Systems Equipment

Test Procedures

Proposed test procedures for piping hydrostatic test, ductwork leak test, and performance tests of systems, at least 2 weeks prior to the start of related testing.

System Diagrams, **G, ED**

Proposed diagrams, at least 2 weeks prior to start of related testing. System diagrams that show the layout of equipment, piping, and ductwork, and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system shall be framed under glass or laminated plastic. After approval, these items shall be posted where directed.

Similar Services

Statement demonstrating successful completion of similar services on at least 5 projects of similar size and scope, at least 2 weeks prior to submittal of other items required by this section.

Testing, Adjusting and Balancing

Proposed test schedules for hydrostatic test of piping, ductwork leak test, and performance tests, at least 2 weeks prior to the start of related testing.

Field Training

Proposed schedule for field training, at least 2 weeks prior to the start of related training.

SD-06 Test Reports

Performance Tests

Test reports for the piping hydrostatic test, ductwork leak test, and performance tests in booklet form, upon completion of testing. Reports shall document phases of tests performed including initial test summary, repairs/adjustments made, and final test results.

SD-07 Certificates

Bolts

Written certification from the bolt manufacturer that the bolts furnished comply with the requirements of this specification. The certification shall include illustrations of product markings, and the number of each type of bolt to be furnished.

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions

Six manuals listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. The manuals shall include the manufacturer's name, model number, parts list, list of parts and tools that should be kept in stock by the owner for routine maintenance including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment.

PART 2 PRODUCTS

2.1 STANDARD PRODUCTS

Components and equipment shall be standard products of a manufacturer regularly engaged in the manufacturing of products that are of a similar material, design and workmanship. The standard products shall have been in satisfactory commercial or industrial use for 2 years before bid opening. The 2-year experience shall include applications of components and equipment under similar circumstances and of similar size. The 2 years must be satisfactorily completed by a product which has been sold or is offered for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures. Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours exclusive of the manufacturer's factory tests, can be shown. The equipment items shall be supported by a service organization.

2.2 ASBESTOS PROHIBITION

Asbestos and asbestos-containing products shall not be used.

2.3 NAMEPLATES

Equipment shall have a nameplate that identifies the manufacturer's name, address, type or style, model or serial number, and catalog number.

2.4 EQUIPMENT GUARDS AND ACCESS

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded according to OSHA requirements. High temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard shall be properly guarded or covered with insulation of a type specified. Catwalks, ladders, and guardrails shall be provided where shown and shall be constructed according to Section 05500 MISCELLANEOUS METAL.

2.5 PIPING COMPONENTS

2.5.1 Copper Tube

Copper tube shall conform to ASTM B 88, and ASTM B 88M, Type K or L.

2.5.2 Joints and Fittings For Copper Tube

Wrought copper and bronze solder-joint pressure fittings shall conform to ASME B16.22 and ASTM B 75M. . Cast copper alloy solder-joint pressure fittings shall conform to ASME B16.18. Cast copper alloy fittings for flared copper tube shall conform to ASME B16.26 and ASTM B 62. Brass or bronze adapters for brazed tubing may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.6 ELECTRICAL WORK

Electrical motor-driven equipment specified shall be provided complete with motor, motor starter, and controls. Unless otherwise specified, electric equipment, including wiring and motor efficiencies, shall be according to Section 16415 ELECTRICAL WORK, INTERIOR. Electrical characteristics and enclosure type shall be as shown. Unless otherwise indicated, motors of 745 W and above shall be high efficiency type. Motor starters shall be provided complete with thermal overload protection and other appurtenances necessary. Each motor shall be according to NEMA MG 1 and shall be of sufficient size to drive the equipment at the specified capacity without exceeding the nameplate rating of the motor. Manual or automatic control and protective or signal devices required for the operation specified, and any control wiring required for controls and devices, but not shown, shall be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controller may be provided to accomplish the same function. Solid-state variable-speed controllers shall be utilized for motors rated 7.45 kW (10 hp) or less.

2.7 CONTROLS

Controls shall be provided as specified in Section 15951 DIRECT DIGITAL CONTROL FOR (HVAC)

2.8 DUCTWORK COMPONENTS

2.8.1 Metal Ductwork

All aspects of metal ductwork construction, including all fittings and components, shall comply with SMACNA HVAC Duct Const Stds unless otherwise specified. Elbows shall be radius type with a centerline radius of 1-1/2 times the width or diameter of the duct where space permits. Otherwise, elbows having a minimum radius equal to the width or diameter of the duct or square elbows with factory fabricated turning vanes may be used. Static pressure Class 125, 250, and 500 Pa (1/2, 1, and 2 inch w.g.) ductwork shall meet the requirements of Seal Class C. Sealants shall conform to fire hazard classification specified in Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Pressure sensitive tape shall not be used as a sealant. Spiral lock seam duct, and flat oval shall be made with duct sealant and locked with not less than 3 equally spaced drive screws or other approved methods indicated in SMACNA HVAC Duct Const Stds. The sealant shall be applied to the exposed male part of the fitting collar so that the sealer will be on the inside of the joint and fully protected by the metal of the duct fitting. One brush coat of the sealant shall be

applied over the outside of the joint to at least 50 mm band width covering all screw heads and joint gap. Dents in the male portion of the slip fitting collar will not be acceptable. Outdoor air intake ducts and plenums shall be fabricated with watertight soldered or brazed joints and seams.

2.8.1.1 Transitions

Diverging air flow transitions shall be made with each side pitched out a maximum of 15 degrees, for an included angle of 30 degrees. Transitions for converging air flow shall be made with each side pitched in a maximum of 30 degrees, for an included angle of 60 degrees, or shall be as indicated. Factory-fabricated reducing fittings for systems using round duct sections when formed to the shape of the ASME short flow nozzle, need not comply with the maximum angles specified.

2.8.1.2 Insulated Nonmetallic Flexible Duct Runouts

Flexible duct runouts shall be used only where indicated. Runout length shall be as shown on the drawings, but shall in no case exceed 3 m. Runouts shall be preinsulated, factory fabricated, and shall comply with NFPA 90A and UL 181. Either field or factory applied vapor barrier shall be provided. Where coil induction or high velocity units are supplied with vertical air inlets, a streamlined and vaned and mitered elbow transition piece shall be provided for connection to the flexible duct or hose. The last elbow to these units, other than the vertical air inlet type, shall be a die-stamped elbow and not a flexible connector. Insulated flexible connectors may be used as runouts. The insulated material and vapor barrier shall conform to the requirements of Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS. The insulation material surface shall not be exposed to the air stream.

2.8.1.3 General Service Duct Connectors

A flexible duct connector approximately 150 mm in width shall be provided where sheet metal connections are made to fans or where ducts of dissimilar metals are connected. For round/oval ducts, the flexible material shall be secured by stainless steel or zinc-coated, iron clinch-type draw bands. For rectangular ducts, the flexible material locked to metal collars shall be installed using normal duct construction methods. The composite connector system shall comply with UL 214 and be classified as "flame-retarded fabrics" in UL Bld Mat Dir.

2.8.1.4 High Temperature Service Duct Connections

Material shall be approximately 2.38 mm thick, 1.2 to 1.36 kg per square meter (35 to 40-ounce per square yard) weight, plain weave fibrous glass cloth with, nickel/chrome wire reinforcement for service in excess of 650 degrees C.

2.8.2 Ductwork Accessories

2.8.2.1 Duct Access Doors

Access doors shall be provided in ductwork and plenums where indicated and at all fire dampers, thermostats, and other apparatus requiring service and inspection in the duct system, and unless otherwise shown, shall conform to SMACNA HVAC Duct Const Stds. Access doors shall be provided upstream and downstream of air flow measuring primaries and cooling coils. Doors shall

be minimum 375 x 450 mm, unless otherwise shown. Where duct size will not accommodate this size door, the doors shall be made as large as practicable. Doors 600 x 600 mm or larger shall be provided with fasteners operable from both sides. Doors in insulated ducts shall be the insulated type.

2.8.2.2 Fire Dampers

Fire dampers shall be 1-1/2 hour fire rated unless otherwise indicated. Fire dampers shall conform to the requirements of NFPA 90A and UL 555. The Contractor shall perform the fire damper test as outlined in NFPA 90A. A pressure relief damper shall be provided upstream of the fire damper. If the ductwork connected to the fire damper is to be insulated then this pressure relief damper shall be factory insulated. Fire dampers shall be automatic operating type and shall have a dynamic rating suitable for the maximum air velocity and pressure differential to which it will be subjected. Fire dampers shall be approved for the specific application, and shall be installed according to their listing. Fire dampers shall be equipped with a steel sleeve or adequately sized frame installed in such a manner that disruption of the attached ductwork, if any, will not impair the operation of the damper. Sleeves or frames shall be equipped with perimeter mounting angles attached on both sides of the wall or floor opening. Ductwork in fire-rated floor-ceiling or roof-ceiling assembly systems with air ducts that pierce the ceiling of the assemblies shall be constructed in conformance with UL Fire Resist Dir. Fire dampers shall be curtain type with damper blades out of the air stream. Dampers shall not reduce the duct or the air transfer opening cross-sectional area. Dampers shall be installed so that the centerline of the damper depth or thickness is located in the centerline of the wall, partition or floor slab depth or thickness. Unless otherwise indicated, the installation details given in SMACNA Install Fire Damp HVAC and in manufacturer's instructions for fire dampers shall be followed.

2.8.2.3 Splitters and Manual Balancing Dampers

Splitters and manual balancing dampers shall be furnished with accessible operating mechanisms. Where operators occur in finished portions of the building, operators shall be chromium plated with all exposed edges rounded. Splitters shall be operated by quadrant operators or 5 mm (3/16 inch) rod brought through the side of the duct with locking setscrew and bushing. Two rods are required on splitters over 200 mm (8 inches). Manual volume control dampers shall be operated by locking-type quadrant operators. Dampers and splitters shall be 2 gauges heavier than the duct in which installed. Unless otherwise indicated, multileaf dampers shall be opposed blade type with maximum blade width of 300 mm. Access doors or panels shall be provided for all concealed damper operators and locking setscrews. Unless otherwise indicated, the locking-type quadrant operators for dampers, when installed on ducts to be thermally insulated, shall be provided with stand-off mounting brackets, bases, or adapters to provide clearance between the duct surface and the operator not less than the thickness of the insulation. Stand-off mounting items shall be integral with the operator or standard accessory of the damper manufacturer. Volume dampers shall be provided where indicated.

2.8.2.4 Air Deflectors and Branch Connections

Air deflectors shall be provided at duct mounted supply outlets, at takeoff or extension collars to supply outlets, at duct branch takeoff connections, and at 90 degree elbows, as well as at locations as indicated on the

drawings or otherwise specified. Conical branch connections or 45 degree entry connections may be used in lieu of deflectors or extractors for branch connections. All air deflectors, except those installed in 90 degree elbows, shall be provided with an approved means of adjustment. Adjustment shall be made from easily accessible means inside the duct or from an adjustment with sturdy lock on the face of the duct. When installed on ducts to be thermally insulated, external adjustments shall be provided with stand-off mounting brackets, integral with the adjustment device, to provide clearance between the duct surface and the adjustment device not less than the thickness of the thermal insulation. Air deflectors shall be factory-fabricated units consisting of curved turning vanes or louver blades designed to provide uniform air distribution and change of direction with minimum turbulence or pressure loss. Air deflectors shall be factory or field assembled. Blade air deflectors, also called blade air extractors, shall be approved factory fabricated units consisting of equalizing grid and adjustable blade and lock. Adjustment shall be easily made from the face of the diffuser or by position adjustment and lock external to the duct. Stand-off brackets shall be provided on insulated ducts and are described herein. Fixed air deflectors, also called turning vanes, shall be provided in 90 degree elbows.

2.8.3 Duct Sleeves, Framed Prepared Openings, Closure Collars

2.8.3.1 Duct Sleeves

Duct sleeves shall be provided for round ducts 375 mm in diameter or less passing through floors, walls, ceilings, or roof, and installed during construction of the floor, wall, ceiling, or roof. Round ducts larger than 375 mm in diameter and square, rectangular, and oval ducts passing through floors, walls, ceilings, or roof shall be installed through framed prepared openings. The Contractor shall be responsible for the proper size and location of sleeves and prepared openings. Sleeves and framed openings are also required where grilles, registers, and diffusers are installed at the openings. Framed prepared openings shall be fabricated from 1.0 mm (20 gauge) galvanized steel, unless otherwise indicated. Where sleeves are installed in bearing walls or partitions, black steel pipe, ASTM A 53/A 53M, Schedule 20 shall be used. Sleeve shall provide 25 mm clearance between the duct and the sleeve or 25 mm clearance between the insulation and the sleeve for insulated ducts.

2.8.3.2 Framed Prepared Openings

Openings shall have 25 mm clearance between the duct and the opening or 25 mm clearance between the insulation and the opening for insulated ducts.

2.8.3.3 Closure Collars

Collars shall be fabricated of galvanized sheet metal not less than 100 mm wide, unless otherwise indicated, and shall be installed on exposed ducts on each side of walls or floors where sleeves or prepared openings are provided. Collars shall be installed tight against surfaces. Collars shall fit snugly around the duct or insulation. Sharp edges of the collar around insulated duct shall be ground smooth to preclude tearing or puncturing the insulation covering or vapor barrier. Collars for round ducts 375 mm in diameter or less shall be fabricated from 1.0 mm (20 gauge) galvanized steel. Collars for round ducts larger than 375 mm and square, and rectangular ducts shall be fabricated from 1.3 mm (18 gauge) galvanized steel. Collars shall be installed with fasteners on maximum 150

mm centers, except that not less than 4 fasteners shall be used.

2.8.4 Diffusers, Registers, and Grilles

Units shall be factory-fabricated of corrosion-resistant steel, or aluminum and shall distribute the specified quantity of air evenly over space intended without causing noticeable drafts, air movement faster than 0.25 m/s (50 fpm) in occupied zone, or dead spots anywhere in the conditioned area. Outlets for diffusion, spread, throw, and noise level shall be as required for specified performance. Performance shall be certified according to ASHRAE 70. Inlets and outlets shall be sound rated and certified according to ASHRAE 70. Sound power level shall be as indicated. Diffusers and registers shall be provided with volume damper with accessible operator, unless otherwise indicated; or if standard with the manufacturer, an automatically controlled device will be acceptable. Volume dampers shall be opposed blade type for all diffusers and registers. Where the inlet and outlet openings are located less than 2 m above the floor, they shall be protected by a grille or screen according to NFPA 90A.

2.8.4.1 Diffusers

Diffuser types shall be as indicated. Ceiling mounted units shall be furnished with anti-smudge devices, unless the diffuser unit minimizes ceiling smudging through design features. Diffusers shall be provided with air deflectors of the type indicated. Ceiling mounted units shall be installed with rims tight against ceiling. Sponge rubber gaskets shall be provided between ceiling and surface mounted diffusers for air leakage control. Suitable trim shall be provided for flush mounted diffusers. Duct collar connecting the duct to diffuser shall be airtight and shall not interfere with volume controller. Return or exhaust units shall be similar to supply diffusers.

2.8.4.2 Registers and Grilles

Units shall be four-way directional-control type, except that return and exhaust registers may be fixed horizontal or vertical louver type similar in appearance to the supply register face. Registers shall be provided with sponge-rubber gasket between flanges and wall or ceiling. Wall supply registers shall be installed at least 150 mm below the ceiling unless otherwise indicated. Return and exhaust registers shall be located 150 mm above the floor unless otherwise indicated. Four-way directional control may be achieved by a grille face which can be rotated in 4 positions or by adjustment of horizontal and vertical vanes. Grilles shall be as specified for registers, without volume control damper.

2.8.5 Louvers

Louvers for installation in exterior walls which are associated with the air supply and distribution system shall be as specified in Section 07600 SHEET METALWORK, GENERAL.

2.8.6 Air Vents, Penthouses, and Goosenecks

Air vents, penthouses, and goosenecks shall be fabricated from stainless steel Type 316 sheets with stainless steel, Type 316, structural shapes. Stainless Steel thickness, reinforcement, and fabrication shall conform to SMACNA HVAC Duct Const Stds. Louver blades shall be accurately fitted and secured to frames. Edges of louver blades shall be folded or beaded for rigidity and baffled to exclude driving rain. Air vents, penthouses, and

goosenecks shall be provided with bird screen.

2.8.7 Bird Screens and Frames

Bird screens shall conform to ASTM E 437, No. 2 mesh, stainless steel. Stainless steel screens shall be rated "light". Frames shall be stainless steel.

2.9 AIR SYSTEMS EQUIPMENT

2.9.1 Fans

Fans shall be tested and rated according to AMCA 210. Fans may be connected to the motors either directly or indirectly with V-belt drive. V-belt drives shall be designed for not less than 150 140 120 percent of the connected driving capacity. Motor sheaves shall be variable pitch for 11 kW (15 hp) and below and fixed pitch as defined by ARI Guideline D. Variable pitch sheaves shall be selected to drive the fan at a speed which will produce the specified capacity when set at the approximate midpoint of the sheave adjustment. When fixed pitch sheaves are furnished, a replaceable sheave shall be provided when needed to achieve system air balance. Motors for V-belt drives shall be provided with adjustable rails or bases. Removable metal guards shall be provided for all exposed V-belt drives, and speed-test openings shall be provided at the center of all rotating shafts. Fans shall be provided with personnel screens or guards on both suction and supply ends, except that the screens need not be provided, unless otherwise indicated, where ducts are connected to the fan. Fan and motor assemblies shall be provided with vibration-isolation supports or mountings as indicated. Vibration-isolation units shall be standard products with published loading ratings. Each fan shall be selected to produce the capacity required at the fan static pressure indicated. Sound power level shall be as indicated. The sound power level values shall be obtained according to AMCA 300. Standard AMCA arrangement, rotation, and discharge shall be as indicated.

2.9.1.1 In-Line Centrifugal Fans

In-line fans shall have centrifugal backward inclined blades, stationary discharge conversion vanes, internal and external belt guards, and adjustable motor mounts. Fans shall be mounted in a welded tubular casing. Air shall enter and leave the fan axially. Inlets shall be streamlined with conversion vanes to eliminate turbulence and provide smooth discharge air flow. Fan bearings and drive shafts shall be enclosed and isolated from the air stream. Fan bearings shall be sealed against dust and dirt and shall be permanently lubricated, and shall be precision self aligning ball or roller type. Bearing life shall be L50 rated at not less than 200,000 hours as defined by AFBMA Std 9 and AFBMA Std 11. Motors shall have open enclosure. Motor starters shall be magnetic across-the-line with general-purpose enclosures. Remote manual switch with pilot indicating light shall be provided where indicated.

2.9.1.2 Air-Curtain Fans

Air curtains shall be provided with a weatherproof housing constructed of high impact plastic or minimum 1.3 mm (18 gauge) rigid welded steel. Fan wheels shall be backward curved, non-overloading, centrifugal type and accurately balanced statically and dynamically. Motors shall have totally enclosed fan cooled enclosures. Motor starters shall be remote manual type with weather-resistant enclosure actuated when the doorway served is open.

The air curtains shall attain the air velocities specified within 2 seconds following activation. Air intake and discharge openings shall be protected by bird screens. Air curtain unit or a multiple unit installation shall be at least as wide as the opening to be protected. The air discharge openings shall be so designed and equipped as to permit outward adjustment of the discharge air. Adjustment and installation placement shall be according to the manufacturer's written recommendation. Directional controls on air curtains for service windows shall be designed to be easily cleanable or readily removable. Air curtains shall be designed to prevent the adjustment of the air velocities specified. The interior surfaces of the air curtain units shall be accessible for cleaning. Certified test data indicating that the fan will provide the air velocities required when fan is mounted as indicated shall be furnished. Air curtains designed as fly fans shall be provided where indicated. Air curtains designed for use in service entranceways shall develop an air curtain not less than 75 mm thick at the discharge nozzle. The air velocity shall be not less than 8 m/s across the entire entryway when measured 900 mm above the floor.

2.9.2 Air Filters

Air filters shall be listed according to requirements of UL 900.

2.9.2.1 Replaceable Media Filters

Replaceable media filters shall be the dry-media viscous adhesive type, of the size required to suit the application. Filtering media shall be not less than 50 mm (2 inches) thick fibrous glass media pad supported by a structural wire grid or woven wire mesh. Pad shall be enclosed in a holding frame of not less than 1.6 mm (16 gauge) galvanized steel, and equipped with quick-opening mechanism for changing filter media. The air flow capacity of the filter shall be based on net filter face velocity not exceeding 1.5 m/s (300 feet per minute), with initial resistance of 32 Pa (0.13 inches water gauge). Average efficiency shall be not less than 30 percent when tested according to ASHRAE 52.1.

2.9.2.2 Holding Frames

Frames shall be fabricated from not lighter than 1.6 mm (16 gauge) sheet steel with rust-inhibitor coating. Each holding frame shall be equipped with suitable filter holding devices. Holding frame seats shall be gasketed. All joints shall be airtight.

2.9.2.3 Filter Gauges

Filter gauges shall be dial type, diaphragm actuated draft and shall be provided for all filter stations, including those filters which are furnished as integral parts of factory fabricated air handling units. Gauges shall be at least 98 mm (3-7/8 inches) in diameter, shall have white dials with black figures, and graduations and shall have a minimum range of 0.25 kPa (1 inch of water) beyond the specified final resistance for the filter bank on which each gauge is applied. Each gauge shall incorporate a screw operated zero adjustment and shall be furnished complete with two static pressure tips with integral compression fittings, two molded plastic vent valves, two 1.5 m (5 foot) minimum lengths of 6.35 mm (1/4 inch) diameter aluminum tubing, and all hardware and accessories for gauge mounting.

2.10 FACTORY PAINTING

Units which are not of galvanized construction according to ASTM A 123/A 123M or ASTM A 924/A 924M shall be factory painted with a corrosion resisting paint finish. Internal and external ferrous metal surfaces shall be cleaned, phosphatized and coated with a paint finish which has been tested according to ASTM B 117, ASTM D 1654, and ASTM D 3359. Evidence of satisfactory paint performance for a minimum of 125 hours for units to be installed indoors and 500 hours for units to be installed outdoors shall be submitted. Rating of failure at the scribe mark shall be not less than 6, average creepage not greater than 3 mm. Rating of the inscribed area shall not be less than 10, no failure. On units constructed of galvanized steel which have been welded, exterior surfaces of welds or welds that have burned through from the interior shall receive a final shop docket of zinc-rich protective paint according to ASTM D 520 Type I.

PART 3 EXECUTION

3.1 INSTALLATION

Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

3.1.1 Supports

3.1.1.1 Seismic Requirements

Equipment shall be supported and braced to resist seismic loads as specified under Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT. Material used for support shall be as specified under Section 05500 MISCELLANEOUS METALS

3.1.2 Flexible Connectors

Pre-insulated flexible connectors and flexible duct shall be attached to other components in accordance with the latest printed instructions of the manufacturer to ensure a vapor tight joint. Hangers, when required to suspend the connectors, shall be of the type recommended by the connector or duct manufacturer and shall be provided at the intervals recommended.

3.1.3 Sleeved and Framed Openings

Space between the sleeved or framed opening and the duct or the duct insulation shall be packed as specified in Section 07840 FIRESTOPPING for fire rated penetrations. For non-fire rated penetrations, the space shall be packed as specified in Section 07900 JOINT SEALING.

3.1.4 Metal Ductwork

Installation shall be according to SMACNA HVAC Duct Const Stds unless otherwise indicated. Duct supports for sheet metal ductwork shall be according to SMACNA HVAC Duct Const Stds, unless otherwise specified. Friction beam clamps indicated in SMACNA HVAC Duct Const Stds shall not be used. Risers on high velocity ducts shall be anchored in the center of the vertical run to allow ends of riser to move due to thermal expansion. Supports on the risers shall allow free vertical movement of the duct. Supports shall be attached only to structural framing members and concrete slabs. Supports shall not be anchored to metal decking unless a means is provided and approved for preventing the anchor from puncturing the metal decking. Where supports are required between structural framing members,

suitable intermediate metal framing shall be provided. Where C-clamps are used, retainer clips shall be provided.

3.1.5 Dust Control

To prevent the accumulation of dust, debris and foreign material during construction, temporary dust control protection shall be provided. The distribution system (supply and return) shall be protected with temporary seal-offs at all inlets and outlets at the end of each day's work. Temporary protection shall remain in place until system is ready for startup.

3.1.6 Insulation

Thickness and application of insulation materials for ductwork, piping, and equipment shall be according to Section 15080 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

3.1.7 Duct Test Holes

Holes with closures or threaded holes with plugs shall be provided in ducts and plenums as indicated or where necessary for the use of pitot tube in balancing the air system. Extensions, complete with cap or plug, shall be provided where the ducts are insulated.

3.2 FIELD PAINTING AND COLOR CODE MARKING

Finish painting of items only primed at the factory, surfaces not specifically noted otherwise, and color code marking for piping shall be as specified in Section 09900 PAINTING, GENERAL.

3.3 PIPING HYDROSTATIC TEST

After cleaning, water piping shall be hydrostatically tested at a pressure equal to 150 percent of the total system operating pressure for period of time sufficient to inspect every joint in the system and in no case less than 2 hours. Leaks shall be repaired and piping retested until test is successful. No loss of pressure will be allowed. Leaks shall be repaired by re-welding or replacing pipe or fittings. Caulking of joints will not be permitted. Concealed and insulated piping shall be tested in place before covering or concealing.

3.4 DUCTWORK LEAK TEST

Ductwork leak test shall be performed for the entire air distribution and exhaust system, including fans, coils, filters, etc. Test procedure, apparatus, and report shall conform to SMACNA Leakage Test Mnl. The maximum allowable leakage rate is 25 l/s (50 cfm). Ductwork leak test shall be completed with satisfactory results prior to applying insulation to ductwork exterior.

3.5 CLEANING AND ADJUSTING

Pipes shall be cleaned free of scale and thoroughly flushed of foreign matter. A temporary bypass shall be provided for water coils to prevent flushing water from passing through coils. Strainers and valves shall be thoroughly cleaned. Prior to testing and balancing, air shall be removed from water systems by operating the air vents. Temporary measures, such as piping the overflow from vents to a collecting vessel shall be taken to

avoid water damage during the venting process. Air vents shall be plugged or capped after the system has been vented. Inside of ducts, plenums, and casing shall be thoroughly cleaned of debris and blown free of small particles of rubbish and dust and then shall be vacuum cleaned before installing outlet faces. Equipment shall be wiped clean, with traces of oil, dust, dirt, or paint spots removed. Temporary filters shall be provided prior to startup of all fans that are operated during construction, and new filters shall be installed after all construction dirt has been removed from the building, and the ducts, plenums, casings, and other items specified have been vacuum cleaned. System shall be maintained in this clean condition until final acceptance. Bearings shall be properly lubricated with oil or grease as recommended by the manufacturer. Belts shall be tightened to proper tension. Control valves and other miscellaneous equipment requiring adjustment shall be adjusted to setting indicated or directed. Fans shall be adjusted to the speed indicated by the manufacturer to meet specified conditions.

3.6 TESTING, ADJUSTING, AND BALANCING

Testing, adjusting, and balancing shall be as specified in Section 15990 TESTING, ADJUSTING AND BALANCING OF HVAC SYSTEMS. Testing, adjusting, and balancing shall begin only when the air supply and distribution, including controls, has been completed, with the exception of performance tests.

3.7 PERFORMANCE TESTS

After testing, adjusting, and balancing has been completed as specified, each system shall be tested as a whole to see that all items perform as integral parts of the system and temperatures and conditions are evenly controlled throughout the building. Corrections and adjustments shall be made as necessary to produce the conditions indicated or specified. Capacity tests and general operating tests shall be conducted by an experienced engineer. Tests shall cover a period of not less than 5 days for each system and shall demonstrate that the entire system is functioning according to the specifications. Coincidental chart recordings shall be made at points indicated on the drawings for the duration of the time period and shall record the temperature at space thermostats or space sensors, the humidity at space humidistats or space sensors and the ambient temperature and humidity in a shaded and weather protected area.

3.8 FIELD TRAINING

The Contractor shall conduct a training course for operating and maintenance personnel as designated by the Contracting Officer. Training shall be provided for a period of 8 hours of normal working time and shall start after the system is functionally complete but prior to the performance tests. The field instruction shall cover all of the items contained in the approved Operating and Maintenance Instructions.

-- End of Section --

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DIVISION 15 - MECHANICAL

SECTION 15990

TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS

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SECTION 15990

TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ASSOCIATED AIR BALANCE COUNCIL (AABC)

AABC MN-1	(1989) National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems

NATIONAL ENVIRONMENTAL BALANCING BUREAU (NEBB)

NEBB Procedural Stds	(1991) Procedural Standards for Testing Adjusting Balancing of Environmental Systems

1.2 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

TAB Schematic Drawings and Report Forms

Three copies of the TAB Schematic Drawings and Report Forms, no later than 21 days prior to the start of TAB field measurements.

SD-03 Product Data

TAB Related HVAC Submittals

A list of the TAB Related HVAC Submittals, no later than 7 days after the approval of the TAB Specialist.

TAB Procedures, **G, ED**.

Proposed procedures for TAB, submitted with the TAB Schematic Drawings and Report Forms.

Calibration

List of each instrument to be used during TAB, stating

calibration requirements required or recommended by both the TAB Standard and the instrument manufacturer and the actual calibration history of the instrument, submitted with the TAB Procedures. The calibration history shall include dates calibrated, the qualifications of the calibration laboratory, and the calibration procedures used.

Systems Readiness Check

Proposed date and time to begin the Systems Readiness Check, no later than 7 days prior to the start of the Systems Readiness Check.

TAB Execution, **G, ED**.

Proposed date and time to begin field measurements, making adjustments, etc., for the TAB Report, submitted with the Systems Readiness Check Report.

TAB Verification, **G, ED**.

Proposed date and time to begin the TAB Verification, submitted with the TAB Report.

SD-06 Test Reports

Design Review Report, **G, ED**.

A copy of the Design Review Report, no later than 14 days after approval of the TAB Firm and the TAB Specialist.

Systems Readiness Check, **G, ED**.

A copy of completed checklists for each system, each signed by the TAB Specialist, at least 7 days prior to the start of TAB Execution. All items in the Systems Readiness Check Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

TAB Report, **G, ED**.

Three copies of the completed TAB Reports, no later that 7 days after the execution of TAB. All items in the TAB Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

TAB Verification Report, **G, ED**.

Three copies of the completed TAB Verification Report, no later that 7 days after the execution of TAB Verification. All items in the TAB Verification Report shall be signed by the TAB Specialist and shall bear the seal of the Professional Society or National Association used as the TAB Standard.

SD-07 Certificates

Ductwork Leak Testing

A written statement signed by the TAB Specialist certifying that the TAB Specialist witnessed the Ductwork Leak Testing, it was successfully completed, and that there are no known deficiencies related to the ductwork installation that will prevent TAB from producing satisfactory results.

TAB Firm, **G, ED**.

Certification of the proposed TAB Firm's qualifications by either AABC or NEBB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed TAB Firm or disciplinary action taken by AABC or NEBB against the proposed TAB Firm shall be described in detail.

TAB Specialist, **G, ED**.

Certification of the proposed TAB Specialist's qualifications by either AABC or NEBB to perform the duties specified herein and in other related Sections, no later than 21 days after the Notice to Proceed. The documentation shall include the date that the Certification was initially granted and the date that the current Certification expires. Any lapses in Certification of the proposed TAB Specialist or disciplinary action taken by AABC or NEBB against the proposed TAB Specialist shall be described in detail.

1.3 SIMILAR TERMS

In some instances, terminology differs between the Contract and the TAB Standard primarily because the intent of this Section is to use the industry standards specified, along with additional requirements listed herein to produce optimal results. The following table of similar terms is provided for clarification only. Contract requirements take precedent over the corresponding AABC or NEBB requirements where differences exist.

SIMILAR TERMS

Contract Term	AABC Term	NEBB Term
TAB Standard	National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems	Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
TAB Specialist	TAB Engineer	TAB Supervisor
Systems Readiness Check	Construction Phase Inspection	Field Readiness Check & Preliminary Field Procedures.

1.4 TAB STANDARD

TAB shall be performed in accordance with the requirements of the standard

under which the TAB Firm's qualifications are approved, i.e., AABC MN-1or NEBB Procedural Stds, unless otherwise specified herein. All recommendations and suggested practices contained in the TAB Standard shall be considered mandatory. The provisions of the TAB Standard, including checklists, report forms, etc., shall, as nearly as practical, be used to satisfy the Contract requirements. The TAB Standard shall be used for all aspects of TAB, including qualifications for the TAB Firm and Specialist and calibration of TAB instruments. Where the instrument manufacturer calibration recommendations are more stringent than those listed in the TAB Standard, the manufacturer's recommendations shall be adhered to. All quality assurance provisions of the TAB Standard such as performance guarantees shall be part of this contract. For systems or system components not covered in the TAB Standard, TAB procedures shall be developed by the TAB Specialist. Where new procedures, requirements, etc., applicable to the Contract requirements have been published or adopted by the body responsible for the TAB Standard used (AABC or NEBB), the requirements and recommendations contained in these procedures and requirements shall be considered mandatory.

1.5 QUALIFICATIONS

1.5.1 TAB Firm

The TAB Firm shall be either a member of AABC or certified by the NEBB and certified in all categories and functions where measurements or performance are specified on the plans and specifications, including TAB of environmental systems. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the firm loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another TAB Firm for approval. Any firm that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections to be performed by the TAB Firm shall be considered invalid if the TAB Firm loses its certification prior to Contract completion and must be performed by an approved successor. These TAB services are to assist the prime Contractor in performing the quality oversight for which it is responsible. The TAB Firm shall be a subcontractor of the prime Contractor, and shall report to and be paid by the prime Contractor.

1.5.2 TAB Specialist

The TAB Specialist shall be either a member of AABC or an experienced technician of the Firm certified by the NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the Contractor shall immediately notify the Contracting Officer and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB Specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by the approved successor.

1.6 TAB SPECIALIST RESPONSIBILITIES

All TAB work specified herein and in related sections shall be performed under the direct guidance of the TAB Specialist. The TAB Specialist shall participate in the commissioning process specified in Section 15995 COMMISSIONING OF HVAC SYSTEMS.

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 DESIGN REVIEW

The TAB Specialist shall review the Contract Plans and Specifications and advise the Contracting Officer of any deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a Design Review Report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

3.2 TAB RELATED HVAC SUBMITTALS

The TAB Specialist shall prepare a list of the submittals from the Contract Submittal Register that relate to the successful accomplishment of all HVAC TAB. The submittals identified on this list shall be accompanied by a letter of approval signed and dated by the TAB Specialist when submitted to the Government. The TAB Specialist shall also ensure that the location and details of ports, terminals, connections, etc., necessary to perform TAB are identified on the submittals.

3.3 TAB SCHEMATIC DRAWINGS AND REPORT FORMS

A schematic drawing showing each system component, including balancing devices, shall be provided for each system. Each drawing shall be accompanied by a copy of all report forms required by the TAB Standard used for that system. Where applicable, the acceptable range of operation or appropriate setting for each component shall be included on the forms or as an attachment to the forms. The schematic drawings shall identify all testing points and cross reference these points to the report forms and procedures.

3.4 DUCTWORK LEAK TESTING

The TAB Specialist shall witness the Ductwork Leak Testing specified in Section 15895 AIR SUPPLY, DISTRIBUTION, VENTILATION, AND EXHAUST SYSTEM and approve the results as specified in Paragraph TAB RELATED HVAC SUBMITTALS.

3.5 TESTING, ADJUSTING, AND BALANCING

3.5.1 TAB Procedures

Step by step procedures for each measurement required during TAB Execution shall be provided. The procedures shall be oriented such that there is a separate section for each system. The procedures shall include measures to ensure that each system performs as specified in all operating modes, interactions with other components (such as exhaust fans, kitchen hoods, fume hoods, relief vents, etc.) and systems, and with all seasonal operating differences, diversity, simulated loads, and pressure relationships required.

3.5.2 Systems Readiness Check

The TAB Specialist shall inspect each system to ensure that it is complete, including installation and operation of controls, and that all aspects of the facility that have any bearing on the HVAC systems, including installation of ceilings, walls, windows, doors, and partitions, are complete to the extent that TAB results will not be affected by any detail or touch-up work remaining. The TAB Specialist shall also verify that all items such as ductwork and piping ports, terminals, connections, etc., necessary to perform TAB shall be complete during the Systems Readiness Check.

3.5.3 Preparation of TAB Report

Preparation of the TAB Report shall begin only when the Systems Readiness Report has been approved. The Report shall be oriented so that there is a separate section for each system. The Report shall include a copy of the appropriate approved Schematic Drawings and TAB Related Submittals, such as pump curves, fan curves, etc., along with the completed report forms for each system. The operating points measured during successful TAB Execution and the theoretical operating points listed in the approved submittals shall be marked on the performance curves and tables. Where possible, adjustments shall be made using an "industry standard" technique which would result in the greatest energy savings, such as adjusting the speed of a fan instead of throttling the flow. Any deficiencies outside of the realm of normal adjustments and balancing during TAB Execution shall be noted along with a description of corrective action performed to bring the measurement into the specified range. If, for any reason, the TAB Specialist determines during TAB Execution that any Contract requirement cannot be met, the TAB Specialist shall immediately provide a written description of the deficiency and the corresponding proposed corrective action necessary for proper system operation to the Contracting Officer.

3.5.4 TAB Verification

The TAB Specialist shall recheck ten percent of the measurements listed in the Tab Report and prepare a TAB Verification Report. The measurements selected for verification and the individuals that witness the verification will be selected by the Contracting Officer's Representative (COR). The measurements will be recorded in the same manner as required for the TAB Report. All measurements that fall outside the acceptable operating range specified shall be accompanied by an explanation as to why the measurement does not correlate with that listed in the TAB Report and a description of corrective action performed to bring the measurement into the specified range. The TAB Specialist shall update the original TAB report to reflect any changes or differences noted in the TAB verification report and submit the updated TAB report. If over 20 percent of the measurements selected by the COR for verification fall outside of the acceptable operating range specified, the COR will select an additional ten percent for verification. If over 20 percent of the total tested (including both test groups) fall outside of the acceptable range, the TAB Report shall be considered invalid and all contract TAB work shall be repeated beginning with the Systems Readiness Check.

3.5.5 Marking of Setting

Following approval of TAB Verification Report, the setting of all HVAC adjustment devices including valves, splitters, and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored

if disturbed at any time.

3.5.6 Identification of Test Ports

The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leakage or to maintain integrity of vapor barrier.

-- End of Section --

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DIVISION 15 - MECHANICAL

SECTION 15995

COMMISSIONING OF MECHANICAL SYSTEMS

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SECTION 15995

COMMISSIONING OF MECHANICAL SYSTEMS

PART 1 GENERAL

1.1 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-03 Product Data

Commissioning Team

List of team members who will represent the Contractor in the pre-commissioning checks and functional performance testing, at least 2 weeks prior to the start of pre-commissioning checks. Proposed revision to the list, prior to the start of the impacted work.

Test Procedures

Detailed procedures for pre-commissioning checks and functional performance tests, at least 4 weeks prior to the start of pre-commissioning checks.

Test Schedule, **G, ED**.

Schedule for pre-commissioning checks and functional performance tests, at least 2 weeks prior to the start of pre-commissioning checks.

SD-06 Test Reports

Test Reports, **G, ED**.

Completed pre-commissioning checklists and functional performance test checklists organized by system and by subsystem and submitted as one package. The results of failed tests shall be included along with a description of the corrective action taken.

1.2 SEQUENCING AND SCHEDULING

The work described in this Section shall begin only after all work required in related Sections, including Section 15951DIRECT DIGITAL FOR HVAC AND REFRIGERATION SYSTEM and Section 15990 TESTING, ADJUSTING AND BALANCING OF HVAC SYSTEMS, has been successfully completed, and all test and inspection reports and operation and maintenance manuals required in these Sections have been submitted and approved.Seismic details shall be in accordance

with Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 15070 SEISMIC PROTECTION FOR MECHANICAL EQUIPMENT

PART 2 PRODUCTS (Not Applicable)

PART 3 EXECUTION

3.1 COMMISSIONING TEAM AND CHECKLISTS

The Contractor shall designate team members to participate in the pre-commissioning checks and the functional performance testing specified herein. In addition, the Government will be represented by a representative of the Contracting Officer, the Design Agent's Representative, and the Using Agency. The team members shall be as follows:

Designation	Function
Q	Contractor's Chief Quality Control Representative
M	Contractor's Mechanical Representative
E	Contractor's Electrical Representative
T	Contractor's Testing, Adjusting, and Balancing Representative
C	Contractor's Controls Representative
D	Design Agent's Representative
O	Contracting Officer's Representative
U	Using Agency's Representative

Each checklist shown in appendices A and B shall be completed by the commissioning team. Acceptance by each commissioning team member of each pre-commissioning checklist item shall be indicated by initials and date unless an "X" is shown indicating that participation by that individual is not required. Acceptance by each commissioning team member of each functional performance test checklist shall be indicated by signature and date.

3.2 TESTS

The pre-commissioning checks and functional performance tests shall be performed in a manner which essentially duplicates the checking, testing, and inspection methods established in the related Sections. Where checking, testing, and inspection methods are not specified in other Sections, methods shall be established which will provide the information required. Testing and verification required by this section shall be performed during the Commissioning phase. Requirements in related Sections are independent from the requirements of this Section and shall not be used to satisfy any of the requirements specified in this Section. The Contractor shall provide all materials, services, and labor required to perform the pre-commissioning checks and functional performance tests. A pre-commissioning check or functional performance test shall be aborted if any system deficiency prevents the successful completion of the test or if any participating non-Government commissioning team member of which participation is specified is not present for the test. The Contractor shall reimburse the Government for all costs associated with effort lost due to tests that are aborted. These costs shall include salary, travel costs and per diem (where applicable) for Government commissioning team members.

3.2.1 Pre-Commissioning Checks

Pre-commissioning checks shall be performed for the items indicated on the checklists in Appendix A. Deficiencies discovered during these checks shall be corrected and retested in accordance with the applicable contract requirements.

3.2.2 Functional Performance Tests

Functional performance tests shall be performed for the items indicated on the checklists in Appendix B. Functional performance tests shall begin only after all pre-commissioning checks have been successfully completed. Tests shall prove all modes of the sequences of operation, and shall verify all other relevant contract requirements. Tests shall begin with equipment or components and shall progress through subsystems to complete systems. Upon failure of any functional performance test checklist item, the Contractor shall correct all deficiencies in accordance with the applicable contract requirements. The checklist shall then be repeated until it has been completed with no errors.

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

PIPING
For Refrigerant Piping System

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Piping complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Piping flushed and cleaned.	___	___	X	___	X	___	___	___
d. Strainers cleaned.	___	___	X	___	X	___	___	___
e. Valves installed as required.	___	___	X	___	X	___	___	___
f. Piping insulated as required.	___	___	X	___	X	___	___	___
g. Thermometers and gauges installed as required.	___	___	X	___	X	___	___	___
h. Verify operation of valves.	___	___	X	___	___	___	___	___
i. Air vents installed as specified.	___	___	X	X	X	___	___	___
j. Flexible connectors installed as specified	___	___	X	X	X	___	___	___
k. Verify that piping has been labeled and valves identified as specified.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Hydrostatic test complete.	___	___	X	___	X	___	___	___
b. TAB operation complete.	___	___	X	___	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

DUCTWORK
For Air Conditioning Unit ACU 1 and 2, EF-1, 2, 3, 4, and 5, SF-1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Ductwork complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Ductwork leak test complete.	___	___	X	___	X	___	___	___
NOTE: The first bracketed item d will be used for Army projects, the second for Air Force projects.								
d. Ductwork insulated as required.	___	___	X	___	X	___	___	___
e. Flexible connectors installed as specified	___	___	X	___	X	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. TAB operation complete.	___	___	X	___	X	___	___	___
b. TAB results within +10% / -0% of L/S	___	___	X	___	X	___	___	___
c. Construction Filters Replaced	___	___	X	___	X	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

PUMPS
For Pump: P-1 AND P-2

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Pumps grouted in place.	___	___	X	X	X	___	___	___
b. Pump vibration isolation devices functional.	___	___	X	X	X	___	___	___
c. Pump/motor coupling alignment verified.	___	___	X	X	X	___	___	___
d. Piping system installed.	___	___	X	X	X	___	___	___
e. Piping system pressure tested.	___	___	X	X	X	___	___	___
f. Pump not leaking.	___	___	X	X	X	___	___	___
g. Field assembled couplings aligned to meet manufacturer's prescribed tolerances.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to pump disconnect.	___	___	___	X	X	___	___	___
b. Pump rotation verified.	___	___	___	X	X	___	___	___
c. Control system interlocks functional.	___	___	___	X	___	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Pressure/temperature gauges installed.	___	___	X	___	X	___	___	___
b. Piping system cleaned.	___	___	X	X	X	___	___	___
c. Glycol water treatment complete.	___	___	X	X	X	___	___	___
d. Water balance complete.	___	___	X	___	X	___	___	___
e. Water balance with design maximum flow.	___	___	X	___	X	___	___	___
f. TAB Report submitted.	___	___	X	___	X	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

PACKAGED REFRIGERATION SYSTEM COMPRESSOR RACKS
For: CR-A and CR-B

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Compressor Rack properly piped.	___	___	X	___	___	___	___	___
b. Refrigerant pipes leak tested.	___	___	X	X	X	___	___	___
c. Verify that refrigerant used complies with specified requirements.	___	___	X	X	X	___	___	___
d. Any damage to unit has been repaired .	___	___	X	___	X	___	___	___
e. Manufacturer's required maintenance clearance provided.	___	___	X	X	X	___	___	___
f. Purge piping installed	___	___	X	X	X	___	___	___
g. Refrigerant monitoring system operational.	___	___	X	X	X	___	___	___
h. Self-Contained breathing apparatus.	___	___	X	X	X	___	___	___
i. Signage provided.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	X	___	___	___	___
b. Power available to unit control panel.	___	___	___	X	___	___	___	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Controls								
a. Factory startup and checkout complete.	___	___	X	X	___	___	___	___
b. Compressor Rack safety/protection devices tested .	___	___	X	X	___	___	___	___
c. Compressor Rack Controller tested.	___	___	___	X	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

HYDRONIC SYSTEM HEATER
For Heater: EHH-1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Heater Glycol piping installed.	___	___	X	X	X	___	___	___
b. Heater glycol piping tested.	___	___	X	X	___	___	___	___
c. Thermostatic mixing valve tested.	___	___	X	X	X	___	___	___
d. Manufacturer's required maintenance clearance provided.	___	___	X	___	___	___	___	___
Startup								
a. Heater system cleaned and filled with glycol solution	___	___	X	___	___	___	___	___
b. Heater safety/protection devices, tested.	___	___	___	X	___	___	___	___
c. Verify that PRV rating conform to heater rating	___	___	___	X	___	___	___	___
d. Glycol piping system functional.	___	___	X	X	___	___	___	___
e. Heater startup and checkout complete.	___	___	X	X	___	___	___	___
f. Heater efficiency demonstrated.	___	___	X	___	X	___	___	___
Electrical								
a. Verify that power disconnect is located within sight of the unit served.	___	___	___	X	___	___	___	___
Controls								
a. Glycol pump interlock installed.	___	___	___	X	___	___	___	___
b. Glycol pump interlock tested.	___	___	___	X	___	___	___	___
c. Glycol heating system balanced.	___	___	X	X	___	___	___	___
d. Glycol heating controls operational.	___	___	X	X	___	___	___	___
e. AHU-1 Installed	___	___	___	X	X	___	___	___
f AHU-1 Tested.	___	___	X	___	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

REFRIGERATION SYSTEM UNIT COOLER
For Unit Cooler: UC-1 Through UC-10

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Refrigerant piping properly connected.	___	___	X	___	___	___	___	___
b. Condensate piping properly connected.	___	___	X	X	X	___	___	___
c. Refrigerant piping pressure tested.	___	___	X	___	___	___	___	___
d. Condensate piping pressure tested.	___	___	X	X	X	___	___	___
e. Heat tracing tested.	___	___	___	X	X	___	___	___
f. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
g. Manufacturer's required maintenance/ operational clearance provided.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	X	___	___	___	___
b. Proper motor rotation verified.	___	___	___	X	X	___	___	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
d. Power available to electric defrost	___	___	___	X	___	___	___	___
Controls								
a. Control valves properly installed.	___	___	X	___	___	___	___	___
b. Control valves operable.	___	___	X	X	___	___	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. TAB Report submitted.	___	___	X	___	X	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

VENTILATION SYSTEM
For Supply and Exhaust Fans: EF-1, 2, 3, 4, 5 and SF-1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Fan belt adjusted.	___	___	X	___	X	___	___	___
b. Vibration isolators installed	___	___	X	X	X	___	___	___
c. Seismic Restraints installed	___	___	X	X	X	___	___	___
Electrical								
a. Power available to fan disconnect.	___	___	___	X	___	___	___	___
b. Proper motor rotation verified.	___	___	___	___	X	___	___	___
c. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
Controls								
a. Control interlocks properly installed.	___	___	___	X	___	___	___	___
b. Control interlocks operable.	___	___	___	X	___	___	___	___
c. Verify proper location and installation of thermostat.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. TAB results +10%/-0% to L/s shown on drawings	___	___	X	___	X	___	___	___
b. TAB Report submitted.	___	___	X	___	X	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

HVAC SYSTEM
Pre-commissioning Checklist - HVAC System Controls

For HVAC System:

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. As-built shop drawings submitted.	___	___	X	X	___	___	___	___
b. Layout of control panel matches drawings.	___	___	X	X	___	___	___	___
c. Framed instructions mounted in or near control panel.	___	___	X	X	___	___	___	___
d. Components properly labeled (on inside and outside of panel).	___	___	X	X	___	___	___	___
e. Control components piped and/or wired to each labeled terminal strip.	___	___	X	X	___	___	___	___
f. EMCS connection made to each labeled terminal strip as shown.	___	___	X	X	___	___	___	___
g. Control wiring and tubing labeled at all terminations, splices, and junctions.	___	___	X	X	___	___	___	___
h. Shielded wiring used on electronic sensors.	__	__	X	X	___	___	___	___
Main Power and Control Air								
a. 110 volt AC power available to panel.	___	___	___	X	___	___	___	___
b. 138 kPa gauge (20 psig) compressed air available to panel.	___	___	X	X	___	___	___	___
Testing, Commissioning, and Balancing								
a. Testing, Commissioning, and Balancing Report submitted.	___	___	X	___	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

HYDRONIC SYSTEM AIR HANDLING UNIT
For Air Handling Unit: AHU-1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Vibration isolation devices installed.	__	___	X	X	X	___	___	___
b. Inspection and access doors are operable and sealed.	__	___	X	___	X	___	___	___
c. Casing undamaged.	__	___	X	X	X	___	___	___
d. Insulation undamaged.	__	___	X	X	X	___	___	___
e. Condensate drainage is unobstructed.	__	___	X	X	X	___	___	___
f. Fan belt adjusted.	__	___	X	___	X	___	___	___
g. Any damage to coil fins has been repaired.	__	__	X	___	X	___	___	___
h. Manufacturer's required maintenance clearance provided.	__	___	X	X	X	___	___	___
i. Seismic restraints installed	__	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	__	___	___	X	X	___	___	___
b. Power available to unit control panel.	__	___	___	X	___	___	___	___
c. Proper motor rotation verified.	___	___	___	__	X	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	__	X	___	___	___	___
e. Power available to electric heating coil.	__	___	___	X	___	___	___	___
Coils								
a. Glycol solution piping properly connected.	___	___	X	___	___	___	___	___
b. Condensate piping properly connected.	___	___	X	X	X	___	___	___
c. Glycol piping pressure tested.	___	___	X	X	___	___	___	___
d. Condensate piping pressure tested.	___	___	X	X	X	___	___	___
e. Air vents installed on water coils as specified.	___	___	X	X	X	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

HYDRONIC SYSTEM AIR HANDLING UNIT
For Air Handling Unit: AHU-1

Checklist Item	Q	M	E	T	C	D	O	U
f. Any damage to coil fins has been repaired.	___	___	X	___	X	___	___	___
Controls								
a. Control valves/actuators properly installed.	___	___	X	___	___	___	___	___
b. Verify proper location and installation of thermostat.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Construction filters removed and replaced.	___	___	X	___	X	___	___	___
b. TAB results +10%/-0% L/s shown on drawings.	___	___	X	___	X	___	___	___
c. TAB Report submitted.	___	___	X	___	X	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

PIPING
For Hydronic Piping System

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Piping complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Piping flushed and cleaned.	___	___	X	___	X	___	___	___
d. Strainers cleaned.	___	___	X	___	X	___	___	___
e. Valves installed as required.	___	___	X	___	X	___	___	___
f. Piping insulated as required.	___	___	X	___	X	___	___	___
g. Thermometers and gauges installed as required.	___	___	X	___	X	___	___	___
h. Verify operation of valves.	___	___	X	___	___	___	___	___
i. Air vents installed as specified.	___	___	X	X	X	___	___	___
j. Flexible connectors installed as specified	___	___	X	X	X	___	___	___
k. Verify that piping has been labeled and valves identified as specified.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Hydrostatic test complete.	___	___	X	___	X	___	___	___
b. TAB operation complete.	___	___	X	___	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

PIPING
For Ice Production Piping System

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Piping complete.	___	___	X	___	X	___	___	___
b. As-built shop drawings submitted.	___	___	X	___	X	___	___	___
c. Piping flushed and cleaned.	___	___	X	___	X	___	___	___
d. Strainers cleaned.	___	___	X	___	X	___	___	___
e. Valves installed as required.	___	___	X	___	X	___	___	___
f. Piping insulated as required.	___	___	X	___	X	___	___	___
g. Thermometers and gauges installed as required.	___	___	X	___	X	___	___	___
h. Verify operation of valves.	___	___	X	___	___	___	___	___
i. Air vents installed as specified.	___	___	X	X	X	___	___	___
j. Flexible connectors installed as specified	___	___	X	X	X	___	___	___
k. Verify that piping has been labeled and valves identified as specified.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Hydrostatic test complete.	___	___	X	___	X	___	___	___
b. TAB operation complete.	___	___	X	___	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

ELECTRICAL WATER HEATER
For Heater: EWH 1

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Water piping installed.	___	___	X	X	X	___	___	___
b. Water piping tested.	___	___	X	___	___	___	___	___
c. Pipe Insulation installed.	___	___	X	___	X	___	___	___
d. Manufacturer's required maintenance clearance provided.	___	___	X	___	___	___	___	___
e. T&P relief installed properly	___	___	X	___	X	___	___	___
f. Piping connections at compressor rack installed properly.	___	___	X	___	X	___	___	___
g. Thermostatic mixing valve temperature set.	___	___	X	___	___	___	___	___
Start-up								
a. Heating system cleaned and filled with water.	___	___	X	___	___	___	___	___
b. Heater safety/protection devices tested.	___	___	___	X	___	___	___	___
c. Water piping system functional.	___	___	X	X	___	___	___	___
d. Heater start-up & checkout complete.	___	___	X	X	___	___	___	___
e. Heater efficiency demonstrated.	___	___	X	___	X	___	___	___
f. Thermostatic mixing valve temperature set.	___	___	X	___	___	___	___	___
Electrical								
a. Verify that power disconnect is located within sight of unit served.	___	___	___	X	___	___	___	___
Controls								
a. Compressor rack heat recovery system operational.	___	___	___	X	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

CONDENSATE PIPE HEAT TRACING
For Condensate Pipe: Heat Tracing

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Heat trace installed properly.	___	___	___	X	___	___	___	___
b. Junction boxes installed properly	___	___	___	X	___	___	___	___
c. Pipe insulation installed	___	___	X	X	X	___	___	___
Electrical								
a. Power available to system.	___	___	___	X	___	___	___	___
b. Verify that power disconnect is located within sight of junction box.	___	___	___	X	___	___	___	___
Controls								
a. Heat trace tested for proper operation.	___	___	___	___	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

AIR COOLED CONDENSER
For: ACC-1 and ACC-2

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Refrigerant leak test completed	___	___	X	X	X	___	___	___
b. Check for casing damage.	___	___	X	X	X	___	___	___
c. Refrigerant charge completed.	___	___	X	X	X	___	___	___
d. Vibration isolation installed.	___	___	X	X	X	___	___	___
e. Check coils for damage.	___	___	X	X	X	___	___	___
f. Manufacturer's required maintenance/ operational clearance provided.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	X	X	___	___	___
b. Power available to unit control panel.	___	___	___	X	___	___	___	___
c. Verify that power disconnect is located within sight of the unit.	___	___	___	X	___	___	___	___
d. Power available motor/fan rotation.	___	___	___	X	___	___	___	___
Controls								
a. Unit safety/protection devices tested.	___	___	X	X	___	___	___	___
b. Control system and interlocks installed.	___	___	X	X	___	___	___	___
c. Control system and interlocks operational.	___	___	X	X	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

ICE MAKER
For Ice maker: IM and 1 and 2

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Unit casing undamaged.	___	___	___	___	___	___	___	___
b. Unit checked for refrigerant leaks.	___	___	___	___	___	___	___	___
c. Check motor for proper rotation.	___	___	___	___	___	___	___	___
d. Operational clearance provided.	___	___	___	___	___	___	___	___
e. Ice maker properly attached to ice dispenser.	___	___	___	___	___	___	___	___
f. Ice bagger properly installed.	___	___	___	___	___	___	___	___
g. Check coin operated ice dispenser for proper operation.	___	___	___	___	___	___	___	___
h. Make up water system tested for leaks	___	___	___	___	___	___	___	___
i. New water filters installed.	___	___	___	___	___	___	___	___
j. Pipe lines and unit disinfected.	___	___	___	___	___	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	___	___	___	___	___
b. Unit control system operational.	___	___	___	___	___	___	___	___
c. Verify that power disconnect is located within sight.	___	___	___	___	___	___	___	___
Testing								
a. Proper ice size.	___	___	___	___	___	___	___	___
b. Proper coin dispenser operation.	___	___	___	___	___	___	___	___
c. Proper bagger operation.	___	___	___	___	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

REFRIGERATION ALARM/MONITORING AND LOW OXYGEN SENSOR SYSTEM CONTROL
For:

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. All control devices are in place, operable, calibrated, and communicating with local control panels and operator interface terminal la(CRT)	___	___	___	X	___	___	___	___
b. Test and verify power supplies, wiring, low voltage transformers allowable voltage drops and related interlocks are available and meet specifications. Continuity had been checked.	___	___	___	X	___	___	___	___
c. Verify that control software programs have been loaded, edited and operation.	___	___	___	X	___	___	___	___
d. Controlled devices, mechanical equipment, actuators,and sensors are complete and operable.	___	___	___	X	___	___	___	___
e. Interrupt building power supply for 30 minutes, re-energize, verify software packages and programming remained intact and operable after interruption.	___	___	___	X	___	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

AIR CONDITIONING UNIT
For: Vertical Self-Contained A/C - ACU 1 and ACU 2

Checklist Item	Q	M	E	T	C	D	O	U
Installation								
a. Unit properly supported.	___	___	X	X	X	___	___	___
b. Check unit for refrigerant leak and proper charge.	___	___	X	___	X	___	___	___
c. Access doors are operable and sealed.	___	___	X	___	X	___	___	___
d. Roof penthoused installed unobstructed.	___	___	X	___	X	___	___	___
e. Casing undamaged.	___	___	X	X	X	___	___	___
f. Insulation undamaged.	___	___	X	X	X	___	___	___
g. Vibration isolation devices installed.	___	___	X	X	X	___	___	___
h. Condensate drainage is unobstructed and routed to floor drain.	___	___	X	X	X	___	___	___
i. Fan belt adjusted.	___	___	X	___	X	___	___	___
j. Manufacturer's required maintenance operational clearance provided.	___	___	X	X	X	___	___	___
Electrical								
a. Power available to unit disconnect.	___	___	___	X	X	___	___	___
b. Proper motor rotation verified.	___	___	___	___	X	___	___	___
c. Proper motor rotation verified.	___	___	___	___	X	___	___	___
d. Verify that power disconnect is located within sight of the unit it controls.	___	___	___	X	___	___	___	___
e. Power available to reheat coils.	___	___	___	___	X	___	___	___
Coils Condenser								
a. Any damage to coil fins have been repaired	___	___	X	___	___	___	___	___
b. Refrigerant piping properly connected.	___	___	X	X	X	___	___	___
c. Check condenser fan for proper rotation.	___	___	X	X	X	___	___	___
d. Refrigerant piping pressure tested.	___	___	X	X	X	___	___	___

APPENDIX A
PRE-COMMISSIONING CHECKLISTS

AIR CONDITIONING UNIT
For: Vertical Self-Contained A/C - ACU 1 and ACU 2

Checklist Item	Q	M	E	T	C	D	O	U
Controls								
a. Unit control system operable and verified.	___	___	___	X	___	___	___	___
b. Verify proper location and installation of thermostat.	___	___	X	___	___	___	___	___
Testing, Adjusting, and Balancing (TAB)								
a. Construction filters removed and replaced.	___	___	X	___	X	___	___	___
b. TAB results +10%/-0% L/s shown on drawings.	___	___	X	___	X	___	___	___
c. TAB results for outside within +10%/-0% L/s shown on drawings.	___	___	X	___	X	___	___	___
d. TAB Report submitted.	___	___	X	___	X	___	___	___

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

PUMPS
For Pump: P-1 and P-2

Prior to performing this checklist, ensure that for closed loop systems, system is pressurized and the make-up gylcol system is operational. Perform test for P-1 then P-2.

1. Activate pump start using control system commands (all possible combination, on/auto, etc.). ON_____ AUTO_____ OFF_____

a. Verify pressure drop across strainer:

Strainer inlet pressure _____ kPa (_____ psig)
Strainer outlet pressure _____ kPa (_____ psig)

b. Verify pump inlet/outlet pressure reading, compare to Testing, Adjusting, and Balancing (TAB) Report, pump design conditions, and pump manufacturer's performance.

	DESIGN	TAB	ACTUAL
Pump inlet pressure (kPa gauge)	_____	_____	_____
Pump outlet pressure (kPa gauge)	_____	_____	_____

c. Operate pump at shutoff and at 100 percent of designed flow when all components are in full flow. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure (kPa gauge)	_____	_____
Pump outlet pressure	_____	_____
Pump flow rate (L/s)	_____	_____

d. Operate pump at shutoff and at minimum flow or when all components are in full by-pass. Plot test readings on pump curve and compare results against readings taken from flow measuring devices.

	SHUTOFF	100 percent
Pump inlet pressure (kPa gauge)	_____	_____
Pump outlet pressure	_____	_____
Pump flow rate (L/s)	_____	_____

2. Verify motor amperage each phase and voltage phase to phase and phase to ground for both the full flow and the minimum flow conditions.

a. Full flow:

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage		_____	_____
Voltage		_____	
Voltage to ground	_____	_____	_____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

PUMPS
For Pump: P-1 and P-2
b. Minimum flow:

	PHASE 1	PHASE 2	PHASE 3
Amperage	_____	_____	_____
Voltage		_____	_____
Voltage		_____	
Voltage to ground	_____	_____	_____

3. Unusual vibration, noise, etc.

_____

_____

4. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative _____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing, Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contracting Officer's Representative _____

Using Agency's Representative _____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

CENTRIFUGAL CHILLER
For Compressor Rack CR-A and CR-B

1. Functional Performance Test: Contractor shall demonstrate operation of compressor racks as per specifications including the following: Start unit cooler to provide load for the compressor racks. Activate controls system start sequence as follows.

a. Control system energizes compressor rack start sequence. _____

b. Compressor rack senses saturated suction temperature above set point, control system activate start._____

c. Verify air cooled condenser controls function, refer to checklist.

_____

d. Compressor rack load to be calculated by controls system. Collect log of load imposed _____

e. Shut-off some of the unit coolers to remove load on the compressor rack system._____

f. Verify compressor unloading sequence after load is removed ._____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing , Adjusting and Balancing Representative
_____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

UNIT COOLERS
For Unit Cooler: UC-1 through UC-10

1. Functional Performance Test: Contractor shall adjust operation of the unit coolers at start-up to lower the temperature in each cold storage room evenly over a 24 hour period to reduce thermal stress. The cold storage spaces shall remain at their specified design temperature once the coolers are started-up. Demonstrate operation of each unit cooler as per specifications including the following:

a. Check unit cooler response to sensor call for cooling. Ensure that the refrigerant solenoid valve operates properly to maintain the space at the design temperature. Adjust set points to ensure that the unit coolers in each space are staged properly to avoid short cycling of the units. Check and operate back-up unit coolers._____

b. Verify amperage, voltage at each fan motor._____

c. Check blower fan cfm._____

d. Verify and adjust proper operation of the defrost controls, evaporator suction pressure regulators, and liquid line subcoolers. _____

e. Verify proper operation of heat tracing on condensate drains._____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing , Adjusting and Balancing Representative
_____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

ICE MAKING SYSTEM
For Ice Maker: IM-1

1. Functional Performance Test: Contractor shall demonstrate operation of the ice making system as per specifications and the following:

a. Perform operational test to verify proper operation of the ice maker. Inspect and monitor refrigeration system for proper operation. Inspect quality of the ice manufactured._____

b. Check for proper operation of the bagger and ice bin agitator._____

c. Check for proper operation of the coin operated dispensing operation._____

d. Check for proper operation of all safeties and emergency shutdowns._____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing , Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

AIR COOLED CONDENSERS
For Air Cooled Condenser: ACC-1 and ACC-2

1. Functional Performance Test: Contractor shall perform a Functional Performance Test of each air cooled condenser s per specification and the following:

a. Activate air cooled condenser fan start using control system command._____

b. After its corresponding compressor rack or air conditioner starts up, control system should cycle fan motors to maintain proper hot gas discharge temperatures. Observe and record functioning of head pressure cycling controls under varying loads._____

c. Verify interlock with compressor rack or air conditioner, condenser fans should operate concurrently when compressor rack or air conditioner is energized._____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing , Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

REFRIGERATION ALARM/MONITORING AND LOW OXYGEN SENSOR
For: Refrigerant Monitoring System

1. Functional Performance Test: Contractor shall verify operation of the controls system as per specification an the following:

a. Temperature sensing element: Verify temperature sensing elements are located per plans, securely mounted where indicated with protective cover. Furnish calibrated digital thermometer -46 to +41 deg C ± 0.5 deg. C accuracy to verify reporting temperature of each sensing element. At each sensing element compare temperature sensed vs. actual temperature. Query each sensing element from local control panel and CRT; allowable variance is 0.5 deg F from digital thermometer._____

b. Follow procedure described in item a) above for all temperature sensing devices._____

c. Simulate power failure to test operation of power failure relays._____

d. Calibrate low oxygen sensor in accordance with the manufacturer=s instructions._____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing , Adjusting and Balancing Representative
_____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS
HYDRONIC UNDERFLOOR WARMING SYSTEM
For Hydronic System Underfloor Warming System: P-1, P-2, AHU-1, EHH-1

1. Functional Performance Test: Contractor shall perform a Functional Performance Test of the system as per specification and the following:

a. Activate and test pumps one at a time, Start using control system command._____

b. Verify pressure drop across strainer, verify strainer is clean. Verify pump inlet/outlet pressure reading, compare to Test and Balance Report, pump design conditions, and pump manufacturer=s performance data. Operate pump at shut-off, 50% and 100% flow. Plot test readings on pump curve. Verify specified flow is obtained. Verify operation of pressure relief._____

c. Verify motor amperage each phase and voltage phase to phase and phase to ground._____

d. Check and report unusual vibration, noise, etc._____

e. Activate hydronic air handler. Verify proper operation of mixing valve, fan, and fan motor._____

f. Shutdown hydronic air handler and activate hydronic heater. Verify proper operation of mixing valve and pressure relief._____

g. After testing of all equipment is complete, coordinate final testing of the system with the refrigeration systems for the freezer spaces operational. Check all equipment and controls for proper operation under actual load._____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing , Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

APPENDIX B
FUNCTIONAL PERFORMANCE TESTS CHECKLISTS

FUNCTIONAL PERFORMANCE TEST CHECKLIST - AIR CONDITIONING UNITS
For Air Conditioning Units: ACU-1 and ACU-2

1. Functional Performance Test: Contractor shall verify operation of the air conditioning units as per specification including the following:

a. Compressor(s) cycle to maintain design room temperatures._____

b. ON dual circuited unit. Verify compressor and control valves sequence to load and unload the compressors under varying load conditions._____

c. Verify unit shut down during fire event initiated by smoke detectors._____

d. Verify air flow balance, outside air/return air flow conditions._____

2. Certification: We the undersigned have witnessed the above functional performance tests and certify that the item tested has met the performance requirements in this section of the specifications.

Signature and Date

Contractor's Chief Quality Control Representative_____

Contractor's Mechanical Representative _____

Contractor's Electrical Representative _____

Contractor's Testing , Adjusting and Balancing Representative _____

Contractor's Controls Representative _____

Contractor's Officer's Representative _____

Using Agency's Representative _____

-- End of Section --